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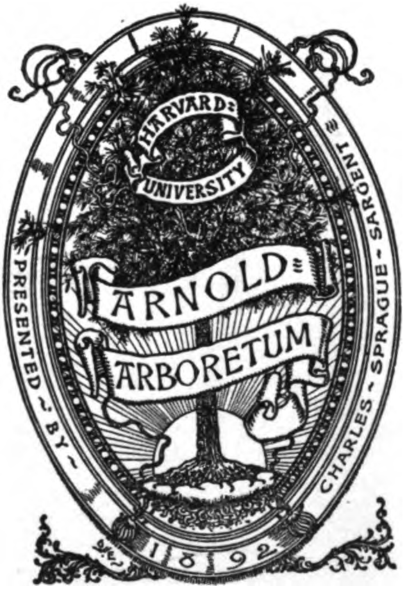
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1892

THE CANADIAN

RECORD OF SCIENCE,

INCLUDING THE PROCEEDINGS OF

THE NATURAL HISTORY SOCIETY OF MONTREAL,

AND REPLACING

THE CANADIAN NATURALIST.

VOL III. (1888-1889.)

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ERRATA.

Page 403, 19th line, for Oxytropus read Oxytropis.
Page 403, 20th line, for Shoenoprasum read Schoenoprasum.
Page 423, 1st line, for Graptotites read Graptolites.
Page 425, 20th line, for dichosomous read dichotomous.
Page 427, 29th line, Kjrulfi read Kjirulfi.
Page 431, 3rd line, for Nemaloxyten read Nematoxylon.
Page 431, 4th line, for tenne read tenue.
Page 431, 13th line, for museptate read non-septate.
Page 431, 20th line, for Celluloxyten read Cellutoxylon.

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THE

CANADIAN RECORD

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VOL. III. JANUARY, 1888. NO. 1.

The Distribution and Physical, and Past-Geological Relations of British North American Plants.

By A. T. Drummond.

(*Conclusion.*)

In illustrating the groups into which the flora of the Dominion may thus be divided, lengthy lists of plants will be avoided. Sufficient examples will be given under each division to show the distinctiveness of the group. It has, however, to be borne in mind that new facts in distribution are always coming to light. The explorations of the country between Lake Superior and the Pacific Coast are, comparatively speaking, recent and limited, and in coming years, with fuller knowledge of the range of each species there, it will be possible to speak with more confidence of, and to group more accurately, the flora of the western half of the continent. At present, in the case of too many species, we have only general locations given, covering a wide stretch of country.

CANADIAN GROUP.

There are no temperate plants in Canada of wide range from Atlantic to Pacific, which are exclusively Canadian, but there are many species of which it may be predicated that their maximum distribution is in this country rather than in the Uuited States. The species which are common to Europe and America, and range to the Pacific, being chiefly northern temperate plants, have, as a rule, the mass of the individuals of each species in Canada. Exclusive of these, however, the following are illustrations of the group:—

Viola blanda, Willd.	Alnus viridis, D. C.
Lathyrus ochroleucus, Hook.	Vicia Americana, Muhl.
Potentilla arguta, Pursh.	Geum triflorum, Pursh.
Rubus triflorus, Rich.	Rosa blanda, Ait.
R. strigosus, Mq.	Cornus stolonifera, Mx.
Cornus Canadensis, L.	Chiogenes hispidula, T. & G.
Nardosmia palmata, Hook.	Menyanthes trifoliata, L.
Kalmia glauca, Ait.	Shepherdia Canadensis, Nutt.
Apocynum androsæmifolium, L.	Betula papyracea, Mx.
Corylus rostrata, Ait.	Smilacina trifolia Desf.

The question naturally suggests itself—Why are many species of wide range, reaching from one side of the continent to the other, whilst many others are circumscribed in area? It is quite clear that the size and weight of the seed, and the appendages which it may have in the shape of wings or silky plumes, to aid in its dissemination, the high winds, the crops, feathers and feet of birds, the different relations of land and water and temperature in past ages—all have been important factors in the extension of the range of plants. But there is another conclusion, the drawing of which analogy warrants. Every plant may be said to have an area where the number of its species and the condition of its growth are at the maximum. Outside of this area, the individuals are found in diminishing numbers until their progress, varying in different directions, finally ceases on every side. The growth, again, of each individual

plant, has its birth in the swelling seed, its maturity when it expands its flower, and its death when, after ripening its seeds, it withers and decays. Similarly, each species has had its beginning, in past ages, in the development and permanency of a well defined variety formed from an already existing species. This new species, thus formed, would, in the course of downward geological time, reach its highest stage of existence as a species,—its period of most active growth and of largest area of distribution, when its ability, under further new conditions, to give rise to further new species, is greatest. Finally, such species has, in after geological time, its period of decline, when the activity of its individuals is gradually lessened and its area of distribution diminished, until extinction comes, leaving to the palæobotanist the duty of revealing its story when he discovers the remains in the clay nodule or the hardened rock. Applying this idea, the older existing species, which are at their maximum of activity, would, with the greater opportunities which in time they had had, have naturally a wider range, under the same set of circumstances, than those which were of more recent creation. Others, again, of the older species, would have passed their maximum of energy and, even though wide of range, would, in each passing century, become more rare. The species of newer creation would, on the other hand, be gradually extending their range wherever circumstances of climate and situation admitted, but, from the shorter lapse of time, would have a more limited range than the older species. Thus, for illustration, *Viola Selkirkii*, Pursh, being common to Europe and America, is probably one of the older species, but being now rare on this continent, may presently be on the decline; *Viola blanda*, Willd., which is a frequent species of wide range, is doubtless about its maximum of energy; whilst *Viola hastata*, Mx., which is uncommon, may be either a recently formed species, or an older species on the decline.

The same idea can be equally well applied in the case of animals.

Forest Group.

The species of this group are, with few exceptions, shrubs and herbaceous plants. That in the far west so many of these plants avoid the open prairies, is an illustration of what might be termed a companionship which nature has arranged between many of the smaller forms of plant life and their towering congeners, the trees, and which brings to light the dependence of the former and the protecting influence of the latter. Amidst the great bluffs of trees which margin the prairie, the general temperature is modified, the play of the sun's rays on the ground is less continuous, the ground itself is more moist, and the high, drying winds of the prairies are greatly diminished in force. Whilst such smaller representativos of plant life find within the line of forests or bluffs such congenial conditions, they afford, as they die, some return to the trees by joining with the trunks and leaves of the trees in enriching the soil by their decay.

The group is illustrated by the following:—

Nuphar luteum, Smith.
Corydalis aurea, Willd.
Claytonia Virginica, L.
Acer spicatum, Lam.
Rhamnus alnifolius, L'Her.
Potentilla tridentata, Sol.
Ribes prostratum, L'Her.
Cicuta bulbifera, L.
Diervilla trifida, Mœnch.
Lonicera ciliata, Muhl.
Viburnum nudum, L.
Erigeron bellidifolium, Muhl.
Diplopappus umbellatus, Hook.
Gaylussacia resinosa, T. & G.
Vaccinium macrocarpon, Ait.
Epigæa repens, L.
Polygonum cilinode, Mx.
Populus tremuloides, Mx.
Abies balsamea, Marsh.
Larix Americana, Mx.

Maritime Group.

As I, several years ago, endeavoured to explain, the species of this group, which are presently found along the shores of the Great Lakes, and of saline ground farther westward, are evidently the remnants of a larger maritime flora which margined the coast in glacial or post-glacial times when the sea made great inroads over Eastern Canada. Their existence in their present positions far inland, may be an argument for the saltness of the great interior seas of these

times, but this does not necessarily follow in the absence of other more direct evidence. The very fact of their flourishing now on the fresh-water lake coasts shows how—no doubt after a severe struggle—they have, but in greatly diminished numbers, adapted themselves to the new conditions in which in the one case the saline element, and in the other, the moist atmosphere of the sea shore, were wanting. We can conceive how, in these distant times, when the sea had receded and when the struggle with changed circumstances had ended in the survival of some, these survivors could, in the usual course, find their way from the former sea shore to the inland seas, and spread themselves around their borders. Some further evidence is needed of the fresh or saline condition of these inland seas of glacial and post-glacial times. In the meantime, it is to be observed that the largest number of the inland maritime plants are found around Lake Ontario and smaller sheets of water east and south of it.

The maritime plants occurring on the coasts of the Great Lakes include the following:—

Ranunculus cymbalaria, Pursh.	Euphorbia polygonifolia, L.
Cakile Americana, Nutt.	Myrica cerifera, L.
Hudsonia ericoides, L.	Naias major, All.
H. tomentosa, Nutt.	Ruppia maritima, L.
Spergularia media, Presl.	Triglochin maritimum, L.
Hibiscus Moscheutos, L.	T. palustre, L.
Lathyrus maritimus, Bigel.	Juncus Gerardi, Lois.
Atriplex hastata, L.	Sciopus maritimus, L.
Salicornia herbacea, L.	Calamagrostis arenaria, Roth.
Polygonum aviculare, L.	Leptochloa fascicularis, Gray.
Var. littorale, Link.	Spartina stricta, Roth.
P. articulatum, L.	Var. alternifolia, Gray.
Rumex maritimus, L.	Hordeum jubatum, L.

These inland maritime plants can be regarded as one of our older floras, dating back to at least the times of the Leda clays.

EASTERN COAST GROUP.

The following species may be taken as illustrative of this group in Canada. Where they occur in the United States, they have, with two exceptions, a similar range there:—

Hudsonia ericoides, L.	Gnaphalium sylvaticum, L.
Potentilla nemoralis, Nest.	Gaylussacia dumosa, T. & G.
Rosa nitida, Willd.	Calluna vulgaris, Salisb.
Lythrum salicaria, L.	Kalmia latifolia, L., if localities confirmed.
Aster radula. Ait.	Rhodora Canadensis, L.
A. Novi-Belgii, L.	Betula alba var. populifolia, Spach.
A. tardiflorus, L.	Corema Conradii, Torr.
Dipplopappus linariifolius, Hook.	Solidago puberula, Nutt.
Solidago speciosa, Nutt.	

Some of the special influences which limit the range of the species of this group, are not difficult to conjecture. The Appalachian chain of mountains has no doubt acted as a barrier to the westward progress of many plants, as it has to the eastern extension of many others. The more equable temperature, the moister atmosphere and the prevailing fogs, so pronounced on the immediate coast, especially of Nova Scotia, New Brunswick, Newfoundland and the St. Lawrence estuary, must exercise some influence inland as well, though this influence necessarily diminishes as the distance from the coast increases. A marked illustration of this influence will be referred to in the case of the British Columbia plants.

The most remarkable feature, however, in the eastern coast distribution, is the absence of such a large number of the familiar trees, shrubs and herbaceous plants of the Upper St. Lawrence valley. It is quite probable that the same local causes which favour the distribution of the species of this eastern coast group, may be prejudicial to the extension towards the coast, of many of these more inland plants now absent. Causes which affect even human life differently in different individuals, may equally well, even in a greater degree, we can readily suppose, have different effects on the plants of different species. It has always appeared to me probable that the dense fogs of the Nova Scotia coast may have something to do with the absence of such a northern and widely ranging tree as the white cedar, *Thuja occidentalis*, L.; and a similar cause, and the moister atmosphere generally, may have also some influence in limiting the range in both New Brunswick and

Nova Scotia of the white oak and butternut. A more immediate cause for the absence of Ontario and Eastern Quebec plants is, however, the lower temperature arising from the Labrador current, which, by a branch through the Straits of Belle Isle, extends its influence up the St. Lawrence on both sides towards Quebec, whilst its main stream, after washing the eastern coasts of Newfoundland, spreads along the Nova Scotia and New Brunswick coasts in its course south westward. Of the effect of this cold current on plant life on the immediate coast, there is no question.

ERIE GROUP.

The area in Canada in which this group of plants is distributed, is practically limited to that part of Ontario lying between Lake Erie and a line drawn from the eastern end of Lake Ontario to the mouth of the St. Clair River. This area is in the latitude of Southern Michigan and of Central and Southern New York State, and forms the most southern portion of Canada. It has, further, its climate modified by the proximity of the three lakes, Huron, Erie and Ontario. These facts sufficiently account for the middle temperate nature of the flora which, in its relations to Canada, has here been termed the Erie group.

The south-western peninsula of Ontario is also marked by the great variety in species of its trees, and by, in the past, their remarkable growth. It is possible to find on a single farm of two hundred acres, more than half of the species of trees which occur in Ontario. The peninsula is now well denuded of its large trees, but fifty or more years ago its splendid forests were the admiration of travellers. Near where the present city of London stands, were white pines six feet in diameter and one hundred and sixty feet in height, and magnificent button-woods averaging about eighteen feet in girth and sending upwards straight stems to a height of even thirty feet before branching. Farther north, these button-woods were sometimes found of nearly twelve feet in diameter. Oaks in the district watered by the River Thames, varied from ten to fifteen feet in circumference, and had often forty-five to fifty feet of clear, straight

stems. The stately elms were in great abundance and of remarkable size, attaining occasionally even twenty-five feet in circumference, whilst the tulip trees around Niagara were not only of considerable height, but were not unfrequently ten to twelve feet through.

The following plants are characteristic of this group:—

Liriodendron tulipifera, L.	Aster Shortii, Boot.
Asimina triloba, Dunal.	Solidago Riddellii, Frank.
Nelumbeum luteum, Willd.	Coreopsis tripterus, L.
Corydalis flavula, Raf.	Gerardia flava, L.
Euonymus Americanus, L.	Hydrophyllum appendiculatum, Mx.
Polygala incarnata, L.	Phlox subulata, L.
Agrimonia parviflora, Ait.	Sassafras officinale, Nees.
Cornus florida, L.	Morus rubra, L.
Nyssa multiflora, Wang.	Castanea vesca, L.

St. Lawrence Group.

It is a remarkable fact, pointed out by me some years ago, that a considerable number of the forest trees of Ontario in their range westward, come to an abrupt termination in Canada in the district lying between Lake Superior and the Lake of the Woods, whilst others are hardly seen west of the Sault St. Marie. In Ontario, there are sixty-nine species of forest trees, of which thirty-five are known either on the north or the south shores of Lake Superior. Of these thirty-five, only fourteen cross into the prairie region in central and southern Manitoba. Similar circumstances are apparent in an even greater degree among the shrubs and herbaceous plants. In Canada, many of these seem to be limited in their westward course by the outlet of Lake Superior, though in the United States they range more or less along the southern shores of that lake. The reason of this limit in Canada is readily understood when the rocky, hilly nature of the country around the northern coasts of Lake Superior and the boreal character of the climate there are considered.

The rough nature of the country immediately to the westward of Lake Superior—being successions for over three hundred miles of rocky hills, swamps, and large and

small lakes with their connecting rivers—has had, no doubt, its influence in limiting the distribution of many species there. As the prairie is approached, the drier atmosphere, the lighter rainfall, the more prevalent winds and the lower temperature must also have their effect on westward range. It has, however, always appeared to me that the gradual widening, by forest and prairie fires, of the prairie area in a direction easterly from the Red River, has been a leading cause in checking the farther westward extension of the eastern trees, shrubs and herbaceous plants presently confined to the country to the east of the Lake of the Woods- There is much reason to believe that the forest area may have at one time extended westward beyond its present limits in this district, even on what is now treeless prairie, but that fires—no doubt almost entirely since the advent of man there—have, by their annual depredations, extended the prairies gradually eastward, carrying with them the destruction not only of the trees, but of the numerous smaller plants, which are dependent on or influenced by the vicinity of forest areas. Whether the whole prairies have been at one time covered with forest, may be open to question, but, as I have already shown in this journal, there is a strong probability that to forest fires, constantly recurring, may be attributed the gradual enlargement of the prairie area and the formation of new prairies within forest areas. Another visit to the Northwest Territories the past summer, has only confirmed this opinion. It may be objected that were this the case, the stumps and roots of trees should be found on the surface of the prairie. That they have not been more frequently observed is probably due to the rapid decay—one authority gives four years—of the stumps of the poplar, the almost universal tree of the prairies and the immediately surrounding forests.

The brief list hereunder given, enumerates species which range from the Maritime Provinces or Lower St. Lawrence to Lake Superior on either side, or immediately west of it. It is merely in its relations in Canada that the name St. Lawrence is applied to the group.

Acer Pennsylvanicum. L.
Acer saccharinum, Wang.
A. rubrum, L.
Waldsteinia fragrarioides, Tratt.
Dalibarda repens, L.
Rubus villosus, Ait.
Aralia racemosa, L.
Viburnum lantanoides, Mx.
Cephalanthus occidentalis, L.
Fraxinus sambucifolia, Lam.
Quercus rubra, L.
Q. alba, L.
Fagus ferruginea, Ait.
Betula lutea, Mx.
Pinus strobus, L.
P. resinosa, Ait.
Abies Canadensis, Mx.
Arisæma triphyllum, Torr.

Boreal Group.

The localities and their surroundings where the species of this group are found, sufficiently account for their presence now there. In regard to some which occur around the Lake Superior coasts, we can attribute their first migration thither to the same succession of circumstances which gave rise to the small colony of sub-arctic plants more or less associated with them there, and to which allusion will be made when referring to the sub-arctic group.

Illustrations of this group are :—

Anemone parviflora, Mx.
Sagina nodosa, Mey.
Oxytropis campestris, D. C.
Hedysarum boreale, Nutt.
Parnassia palustris, L.
Cornus suecica, L.
Viburnum pauciflorum, Py.
Aster graminifolius, Psh.
Tanacetum Huronense, Nutt.
Artemisia borealis, Pallas.
Arnica Chamissonis, Less.
Lobelia Dortmanna, L.
Pinguicula vulgaris, L.
Rhinanthus Crista-galli, L.
Polygonum viviparum, L.
Pinus Banksiana, L.

Ontario Group.

The species referable to this group, and some of which are confined to Ontario, have, in general, in the United States, a range from Western New England to Wisconsin— a stretch of country in breadth about similar to that of Ontario. They occur chiefly west of the Appalachian chain, and do not appear to cross from the forest lands of Wisconsin into the prairie country of Minnesota and Dakota. Their northward and northeastward range in Canada is probably limited by the colder climate.

The following species sufficiently indicate the group :—

Viola rostrata, Pursh.	Conopholis Americana, Wall.
Ceanothus ovalis, Bigel.	Pentstemon pubescens, Sol.
Staphyllea trifolia, L.	Lophanthus nepetoides, Benth.
Desmodium cuspidatum, T. & G.	Gentiana alba, Muhl.
Lespedeza hirta, Ell.	Asclepias phytolaccoides, Pursh.
Aster ericoides, L.	Montelia tamarascina, Gr.
Lobelia syphilitica, L.	Phytolacca decandra, L.
Vaccinium stamineum, L.	Quercus castanea. Muhl.

A number of representatives of this group, including such plants as *Coreopsis verticillata*, L., *C. lanceolata*. L., *Cacalia tuberosa*, Nutt., *Calamintha Nuttallia*, Benth., and *Scutelaria versicolor*, Nutt., are limited to the vicinity of Lakes Huron and Erie, some extending even to Lake Superior. In the United States, their range is similarly confined to Wisconsin, Illinois, Pennsylvania and southward. It is difficult to give a reason for this. The suggestion which I have already made that, in geological time each species has had its initial, its maximum and its final stage of existence as a species, will, however, I think, explain numerous eccentricities in range everywhere. Whilst many plants, at the present time, are at their maximum stages of activity in individual growth and in reproduction, and have now their maximum breadth of distribution, some are merely in the early or initial stages of this activity, and at the initial points of their ultimate area of range, whilst others must be on the decline when activity in reproducing the species is lessening and the area of distribution is being circumscribed. The range of each species is thus vastly affected. When the stage of decline has been reached, climatal and other causes which would in the ordinary course limit range, would have greater effects on the species than upon others which were in the progressive stage of activity or had reached the maximum.

In these modern times, cultivation itself is having a limiting effect on the distribution of plants as well as animals. The yearly extension of the cultivation of the soil, the demands of commerce, the enlargement of towns and cities, and forest and prairie fires, all contribute annually to this result.

Prairie Group.

The plants peculiar to the prairies are of relatively recent creation—perhaps the most modern group of species existing in America. The prairies, as I have elsewhere stated in this journal, are of comparatively recent origin, and, in some sections, are still in process of formation, and only since this formation of these prairies can we conceive it possible that plants to specially give them an individuality, were called into existence. The variation which gave rise to them was, no doubt, brought about by the very nature of the surroundings—the drier atmosphere, the lighter rainfall, the greater exposure to the sun's rays, the stronger winds, the different and more uniform soil, and the absence of any marked physical surroundings. That many of the flowers there have a wide range is readily understood from the facilities they have for diffusion. The vast expanse of generally treeless, level or relatively level plain, exposed to the uninterrupted play of winds, and the generally uniform soil over great stretches of country, afford an opportunity not elsewhere possible for the diffusion and propagation of seeds. The large representation of the Compositæ—a comparatively modern order—and the vast abundance of the individuals of certain species of this order, are noticeable.

Of the influence of soils on vegetation, both in their chemical and mechanical combinations, there is no question, but this influence in Ontario and Quebec is chiefly observable when considering local floras. Gravel ridges or a stretch of sand will be found frequented or deserted, as the case may be, by certain plants, but the causes which in distant times produced these ridges or this sand operated with similar results here and there over vast sections. Other causes as well, acting simultaneously, or afterwards, mixed and distributed the surface soils everywhere in such a manner that it is difficult to indicate very broad areas of the country from Lake Superior eastward, where special soils, uniformily the same, are alone to be found to the exclusion of their occurrence elsewhere. Other influences acting over greater areas have, therefore, to be songht in study-

ing distribution. There are, however, illustrations of special, more or less uniform soils in the great deposits of black vegetable mould forming these newer Manitoba prairies, and possibly also in the drift deposits of the Missouri Coteau and other such localities, and these may be, in connection, however, with associated influences, found to have some effects on the distribution of species in these sections.

It is unnecessary to individualize this well-known group by a list of species.

Western Prairie Group.

Some species associated in range with true western prairie plants, appear to extend to the foothills of the Rockies, and even in individual cases climb the Rockies themselves. More information is needed with regard to the limits of this group. The following, however, in our present knowledge of their range, illustrate it:—

Cleome integrifolia, T. & G.	Potentilla fastigiata, Nutt.
Arenaria congesta, Cham.	Heuchera parviflora, Nutt.
Malvastrum coccineum, Gray.	Œnothera cæspitosa, Nutt.
Linum rigidum, Psh.	Œnothera triloba, Nutt.
Paronychia sessiliflora, Nutt.	Centunculus minimus, L.
Rhus trilobata, Nutt.	Plantago pusilla, Nutt.
Lupinus Kingii, Watson.	Heliotropium curassavicum, L.
Astragalus kentrophyta, Gray.	Polygonum imbricatum, Nutt.

Western Central Group.

The distribution of the members of this group from the Pacific Coast or the interior of British Columbia eastward towards or into Manitoba, is peculiar, but will be probably found to follow to some extent, the lines of mean temperature. The few species which occur in the Northern United States east of the Mississippi, have a general northwestward range. As more is known of the flora of the Saskatchewan and Peace River countries, the northern limits of distribution of many of the species of this group will, I think, be found to nearly parallel, as some do now, the trends of

mean temperature as they, in a northwestward direction, cross the continent. Others again may find the dry prairies east of the Rockies and the dry interior plateaus of British Columbia equally congenial. Much more information is, however, yet needed.

The plants hereunder, are examples of the group:—

Myosurus aristatus, Benth.	Grindelia squarrosa, Dunal.
Vesicaria Ludoviciana, D. C.	Chrysopsis villosa, Nutt.
Silene Menziesii, Hook.	Helianthus annuus, L.
Astragalus aboriginum, Rich.	Artemisia dracunculoides, Psh.
Potentilla Hippiana, Lehm.	Troximon glaucum, Nutt.
Crataegus Douglasii, Lindl.	Androsace occidentalis, Pursh.
Œnothera albicaulis, Nutt.	Comandra pallida, D. C.
Sedum stenopetalum, Pursh.	Euphorbia serpyllifolia, Pas.

Rocky Mountain Group.

Further enquiry into the range, as well eastward of the mountains, as in British Columbia, of the species presently referable to this group, is needed before the group can be definitely determined. Some of the plants specially referable to it can be classed as boreal, and are known, to the northward, to fringe outward beyond the mountains into the Mackenzie River district, and even towards the coast. There are also some alpine plants, entirely confined in Canada to the Rocky Mountains, and there are others—arctic species—which, whilst they have a considerable range along the arctic coasts between Hudson Bay and Alaska, seem to use the mountains as a ridge along the higher summits of which they extend into latitudes far to the southward.

The following plants presently exemplify the group, in so far as their range is presently known:—

Clematis Douglasii, Hook.	Cymopterus terebrinthus, T. & G.
Aquilegia flavescens, Wats.	Musenium tenuifolium, Nutt.
Lychnis elata, Watson.	Brickellia grandiflora, Nutt.
Astragalus glabriuscula, Gr.	Erigeron bellidiastrum, Nutt.
Oxytropis viscida, Nutt.	Cnicus eriocephalus, Gray.
Rosa Fendleri, Crepin.	C. foliosus, Gray.
Parnassia fimbriata, Kœnig.	C. Hookerianus, Gray.
Bupleurum ranunculoides, L.	Populus angustifolia, James.

British Columbia Flora.

Excluding the sedges and grasses, there are over four hundred species of phænogamous plants in British Columbia, which are not known east of the Rocky Mountains. This number will be considerably increased along both the northern and southern boundaries. The knowledge, however, of this distribution, within the province, of these species is as yet limited, and at this stage it seems better not to draw conclusions too hastily. It may be said generally, that there are species which are well distributed over the province, except probably in the most northern sections, and these may be termed the British Columbia Group. To those confined to the declivities, the valleys and foothills of the Rocky Mountains, and sometimes crossing to the Selkirks, reference has already been made under the term Rocky Mountain Group. Towards the Alaska boundary will yet be found further representatives, not only of the Alaska flora, but of the Asiatic flora as well. There may thus be, in time, sufficient material for an Alaskan or an Asiatic Group. At and towards the southern boundary of the province, are numbers of species familiar in Colorado, Nevada, California, Oregon, or Washington Territory, and whose range across the border into British Columbia is very circumscribed. These, as their centre of distribution is probably in or near Oregon, may be termed the Oregonian Group. Perhaps, however, the most remarkable, as well as the largest flora in British Columbia, is what may be fitly called the Western Coast Group. The greater rainfall, and the general proximity to the coast and to the numerous very deep inlets which indent the coast, are the influences which appear to more or less control the disposition of this flora, and to affect its range also in Washington Territory and Oregon west of the Sierras.

Dr. G. M. Dawson has given considerable attention to the flora of British Columbia and particularly to the distribution of the trees there, and what are here intended by the Western Coast and Oregonian Groups coincide in general terms with areas of his there.

I purpose at an early day, illustrating these British Columbia groups more fully.

Sub-arctic Group.

The Labrador current, which, laden with icebergs, descends from Baffin's Bay, and in a broad stream of three hundred miles, skirts the Labrador coast, sends an off-shoot of its waters through the Straits of Belle Isle, and past Anticosti, up the northern side of the estuary of the St. Lawrence. Meeting, as it proceeds upward, the warmer fresh waters of the river coming from the Great Lakes above, this branch current is diverted to the south coast of the estuary, where it appears as a stream, cold, but somewhat warmer than on the north side, and, proceeding onwards, finally leaves the coast at Gaspe. The effect of this cold current on the vegetation of the shores, is seen in the occurrence of a few arctic and many sub-arctic plants at the Straits of Belle Isle and on Anticosti and the Mingan Islands, and occasional sub-arctic species as far up on the north shore as Tadousac and Murray Bay. Even on the Island of Orleans, near Quebec, there are some boreal forms. The flora of the south shore of the estuary shows the milder character of the current there, whilst that of the Bay of Chaleur appears to prove its comparative absence in that locality.

On the jutting headlands of Lake Superior, and along the bays of its northern coasts, there are both sub-arctic and boreal plants, which appear to form an isolated group there. It is not difficult to account for their continuance in those localities. Northern species delight in a low, equable temperature and a moist atmosphere, and whether this is obtainable on alpine summits or on sea or ocean coasts, there they find a congenial home. The high northern shores of Lake Superior supply these conditions. To account, however, for their original presence there, it is necessary to go back to glacial or post-glacial times, when, with a somewhat colder climate, and with the area of the Great Lakes forming the bed of an inland sea, some sub-arctic and boreal plants found a natural highway along the coasts of this

sea. With lofty mountains to the immediate northward in glacial times, these plants were probably, then, not uncommon. As the waters receded and formed the present lakes, and the climate became as it now is, these northern plants were driven to localities like the headlands of Lake Superior, where conditions were favourable to their continuance. In all other localities they would disappear. Even on Lake Superior, the struggle with changed conditions must have resulted in the extinction there of many of the more northern forms.

The following are some representatives of this group and of the boreal group presently occurring around Lake Superior:—

Draba incana, L.
Viola palustris, L.
Parnassia parviflora, D. C.
Hedysarum boreale, Nutt.
Dryas Drummondii Hook.
Rubus arcticus, L.
R. Chamæmorus, L.
Erigeron acre, L.
Solidago thyrsoidea, Mayer.
Solidago virga-aurea, L.
v. alpina, Big.
Arnica mollis, Hook.
Vaccinium uliginosum, L.
V. cæspitosum, Mx.
Castilleia pallida, Hun.
Euphrasia officinalis, L.
Empetrum nigrum, L.
Tofieldia palustris, Huds.

Arctic Group.

The species of this group include many that are common to Scandinavia, Lapland and the higher Alps, and to our arctic coasts. Whilst numerous arctic plants find their way southward on the higher summits of the Rocky Mountains, on the Pacific side of the continent, and along the Labrador coasts, even up to Anticosti and the Mingan Islands on the Atlantic side, the home of this large group is in the great stretch of country, continental and insular, from the high northern coasts of Labrador, and Greenland to Alaska.

It is unnecessary to illustrate the group.

Relations of the Laramie Flora.

Since the last number of this journal was published, I have had an opportunity of seeing, in the publications of

the Geological Survey of the United States, Lester F. Ward's recent monographs on the flora of the Laramie group, and Sir William Dawson has shown me a proof of his paper on the same subject in the forthcoming transactions of the Royal Society of Canada. Whilst Ward still remains somewhat credulous about the age of the Laramie rocks, Sir William confidently refers them to the Lower Eocene, and concludes also that the Greenland flora usually referred to the Miocene is of later Cretaceous and early Eocene age, though he suggests the question whether this early flora of Greenland, and the floras of the Mackenzie River and North Western States—localities so far apart—may not have been successive within a long epoch in which climatic changes were gradually progressing. Ward's tables indicating the distribution of the Laramie flora not only geographically, but also through geologic time, are interesting to the student of distribution of existing plant life. They show—if the identification be correct—that four, and it may be five, of our living species, viz.: *Viburnum pubescens*, Pursh, *Corylus rostrata*, Ait, *C. Americana*, Watt, *Onoclea sensibilis*, L., and probably *Ginkgo biloba*, L., now of Japan and China, date their origin as far back as at least Eocene times, whilst many of the most familiar genera among the trees and shrubs of the present day were equally well, and in some cases more largely represented in this past period, though appearing for the first time then or in the middle Cretaceous. The tables also bring to light another circumstance of great interest in connection with the discussion, in an earlier part of this paper, on the identity, at the present day, between so many plants in Europe and America. Eleven species—all now extinct—were common to the Eocene of Europe and the Laramie of the United States, whilst two others—also extinct—were common to the European Eocene and to the Greenland beds, considered by Sir William Dawson as later Cretaceous and early Eocene. There is thus some evidence that in the later Cretaceous and Eocene times, not only was the climate in sub-arctic America sufficiently mild to admit there of genera which are, now at least, of a middle or possibly even southern tem-

perate type, but that the relations of land and water were such as to allow migration between Europe and America. Is it unreasonable to suppose that the land then sufficiently elevated above the sea to connect the old world with the new, may have been in a similar position in Pliocene or Post-Pliocene times, and have afforded the facilities then needed for the intermingling of the flora still existing at the present day on the two continents?

Pre-Glacial Drift Plants.

It is interesting to find that in the pre-glacial drift which is thought to be either Pliocene or Pleistocene, and which is spread over a considerable portion of the Middle and Southern States, palæobotanists believe they have recognized three of the existing trees of these States—*Magnolia glauca*, L., *Liquidambar styraciflua*, L., and *Quercus imbricaria*, Mx. These species do not range as far as Canada.

Age of the Canadian Flora.

The relative ages of the species which comprise the Canadian flora form matters rather of speculation, and yet, from the foregoing pages, it will be seen that there are some data on which to found opinions. The conclusions may be thus summarized:—The species of whose presence in the Eocene there is fossil evidence, are the oldest known representatives of the existing flora. Next to these in age, as species, are the plants common to Europe and America, for they were apparently already well distributed at the time of the deposition of the Leda clays. It is probable that many of the Arctic species, which are now limited to America, are equally old, but, just as many plants now have but limited ranges, they had not in these older times found their way beyond the American continent. The American species, not also European in range, but which are denizens of Japan, may be contemporaneous with these Americo-European species, or even earlier in origin. Two of the plants now common to Japan and America date back to the Laramie times. The plants confined in range to British

Columbia, form probably, a later flora brought into existence after the first upheaval of the great parallel chains of mountains there. Following on all of these older floras, but possibly contemporaneous in age with some of them, are the sub-arctic species now on the headlands of Lake Superior and the maritime plants presently on the shores of all of the Great Lakes. The most recent creations are without doubt those species—well represented by compositæ—which frequent more especially the newer prairies of Manitoba.

It is not difficult to see that the development of life on the earth from its dawn to the present, time has been largely influenced by the vast changes which have proceeded gradually but constantly throughout geologic time. In the Laramie age, which was a prolonged period, the great central plains of North America parallel to and east of the Rocky Mountains, and throughout much of the length of the continent, formed a vast, perhaps relatively, shallow inland fresh water sea; during and after the glacial times, whilst an equally great inland, ice-laden sea again prevailed over the northern central parts of the same continent, the southern portions were dry land. In later cretaceous and Eocene times, the climate of the sub-arctic regions was, relatively speaking, warm; in glacial times and since, it has deen so cold as to give a meaning of its own to the name arctic. During the tertiary times, the great dividing ridges forming the Rocky Mountains, were finally raised to their present elevations; whilst, as glacial times were passing away, the then much higher elevations and mountain ranges, which gave rise to the eastern glaciers of this period, were gradually lowered in elevation to what they appear at the present day. And these vast physical and climatic changes in tertiary and post-tertiary times are but an illustration of what has been going on from age to age from the very dawn of life upon the earth. What vast destruction of animals and plants each change must have occasioned! What a struggle for existence must have taken place among those which were left! What adaptation to new conditions in which the survivors constantly

found themselves, must have resulted! What changes in these animals and plants themselves must have been gradually brought about by altered habits and altered food, and by the process of selection which new surroundings would result in! It is not difficult to conceive how new varieties and species would from time to time follow, and how new genera would be created.

[NOTE.—Amid the great mass of material which it has been necessary to bring together in preparing this paper, it is difficult to single out special collectors without referring to all, but I think it right to acknowledge the assistance in regard to our far western flora which Dr. G. M. Dawson and Mr. Macoun's publications haven given me, particularly by indicating in nearly every case the precise localities of occurrence.]—A. T. D.

ON A BASAL SERIES OF CAMBRIAN ROCKS IN ACADIA.

BY G. F. MATTHEW, M.A., F.R.S.C.

[*Read before the Natural History Society of New Brunswick, 1st Nov.* 1887.]

In tracing back the palæozoic systems to their base in the Cambrian, they are found to terminate in various countries at different horizons. Thus in Russia there is no fauna that establishes a horizon older than that of the Olenus beds *; in eastern North America, except along the Atlantic seaboard, the fauna with Olenellus seems to be that which exhibits the earliest trace of life in the Palæozoic formations; a high antiquity has been claimed for the Eophyton sandstones of Sweden, but apparently without sufficient warrant, as I shall endeavour to show further on; but in Wales, remains of animals of several orders have been found in Cambrian slates, equivalent to those of the Longmynd in Shropshire, which are as old, or older, apparently than the Eophyton sandstones.

* I have just learned from Dr. F. Schmidt, of St. Petersburg, that an older horizon, that of *Paradoxides Kjerulfi*, has been found at the top of the "Blue Clay."

Norway, Wales, Newfoundland and the eastern provinces of Canada (Acadia) are countries where the existence of a palæozoic formation older than that holding Paradoxides can now be fairly established. It seems better to regard these rocks as a lower series of the Cambrian system, for in Wales, the corresponding slates and sandstones have long been called Cambrian, whether we take the authority of Sedgwick, Murchison, Hicks or others; and although no physical break has been established in Europe, between the Paradoxides beds and these older Cambrian rocks, this is not the case in America; but, on the contrary, the red rocks at the base of the St. John group (as well as those beneath the Paradoxides beds of Newfoundland) are of a different series from the measures properly referable to this group.

The importance of these subjacent rocks was not fairly understood until explorations, made during the past summer, revealed their great thickness and some evidence of the fauna they contain. In the report on the geology of Southern New Brunswick, 1865, p. 24, this mass of sediments was spoken of as the upper member of the Coldbrook group, and thus distinct from the St. John group; later (Rep. Prog. Geol. Sur. Can., 1870-1, p. 59), it was joined to the latter formation, because the want of conformity existing between the two could not then be established; but it is now found that this red series is unconformable, not only to the St. John group, but also (as had been previously discovered) to the underlying Coldbrook group.

Near the city of St. John, only a few scores of feet in thickness of this formation is to be seen, and even this disappears in the town of Portland, where the St. John group rests directly upon the "upper series" of the Laurentian area. But in tracing these red rocks eastward, around the margin of the St. John Basin of Cambrian rocks, they are found to exhibit a much greater thickness, and at its eastern end there are no less than 1,200 feet in thickness of these underlying measures.

In the valley of the Kennebecasis, these underlying red rocks are wanting, and there the St. John group rests, in some places, on the "upper series," and at others on the old

gneissic rocks of the Laurentian proper. In this valley the lowest beds of the St. John group are with difficulty distinguished from the underlying gneiss, and by the "arkose"-like composition of some layers and by the wave marks and worm trails on others, recall the Eophyton sandstones of Sweden.

In the next valley to the north, that of the Long Reach of the St. John R., the red series underlying the St. John group is found in full force, but has not received a careful examination.

There can be no doubt that this underlying series is one of considerable importance, and as we find it increase in thickness in the St. John Basin, the further east we follow it, until it is covered up by Carboniferous deposits, it is highly probable that the 1,200 feet of measures, at its easternmost exposures, does not represent the entire thickness of the formation.

Mr. Alex. Murray has described a mass of red, green and grey sandstones, with slates of similar color, in his report on the geology of Newfoundland (p. 238), which lie at the base of the Paradoxides beds on that island. He estimates their thickness at 1,500 feet, and states that while they are present in the Cambrian basins of Trinity, St. Mary's and Placentia bays, they are absent from those of Conception and Fortune bays. Hence we may infer that these lower sandstones, etc., form a lower series unconformable to the beds carrying Paradoxides. The only fossils reported from these rocks are "obscure forms like fucoids, and peculiar markings resembling annelid tracks." The conglomerate at Manuel Brook, Conception Bay, and the sandstones elsewhere at a corresponding horizon, appear to mark the break between this series and the higher part of the Cambrian rocks in Newfoundland.

Between the beds of this lower formation of the Cambrian system in New Brunswick, and those which lie at the same horizon in Norway and Wales, there is a strong resemblance in mineral character; in these countries, feldspathic sandstones, often of a red color, with some conglomerates and more or less of red and green shales or slates, make up the greater part of this basal formation.

Prof. Theodore Kjerulf has very carefully investigated this part of the Cambrian in Norway, where it is known as the Sparagmite formation. He divides it into two parts, viz.:—1. (Upper) Blue quartzite and quartziferous sandstones 310-500 metres (about 1000-1600 feet) thick. 2. (Lower) Grey and red sparagmite, also conglomerates and sandstones 630-910 metres (2000-2900 feet) thick.

In this formation, no fossils are known in the lower division, but they are found at the base of the upper division. The genera correspond to those of Bands *b* and *c* of Division 1 of the St. John group, and therefore the upper division of the Sparagmite formation is of Primordeal age, and the lower will correspond to the underlying series of red rocks of the St. John Basin.

It seems doubtful if this lower part of the Cambrian system is at all represented in Sweden. Here the oldest beds were first described as the "Fucoidal Sandstone"; but as the greatest thickness of this sandstone at several localities where it was measured by Hisinger, Wallin and Sidenbladh, did not exceed eighty feet, it seems impossible that this sandstone represents the great mass of sediments which in Norway, Britain, Newfoundland and Acadia, lie at the base of the Cambrian system; it seems rather to correspond to the grey sandstones and dark grey sandy shales of Bands *a* and *b* of Division 1 of the St. John group, which in their eastern exposures have a thickness, the former of about 200 and the latter of some 140 feet.

In Wales is to be found a series of beds, which, perhaps, more nearly than any others, correspond in mineral characters, and in the evidence which they contain of the presence of living forms at this period, to the Lower Cambrian series of Acadia. To the zeal and acumen of Dr. Henry Hicks, science is indebted for the discovery which made plain the existence of a somewhat varied fauna in these very ancient rocks, previously known only to have worm burrows. By the organic remains which they contain, consisting of crustaceans, brachiopods, etc., he was able, on palæontological grounds, to divide the obscure slates of the Lower Cambrian formation at St. David's into the Solva Group

(upper) and the Caerfai (lower). The upper group has a thickness of 1800 feet, and in a former publication I have shown that its fauna is essentially equivalent to that of Band *c* of Division 1 of the St. John group; but from the thickness of the Solva group, it seems probable that it contains also the equivalent of the Band *b* and perhaps of Band *a*. This being the case, we may infer that the Caerfai group, which has a thickness of about 1600 feet, corresponds to the lower series of the Cambrian system in Acadia. But the Caerfai group in Wales is not known to be unconformable to the rest of the Cambrian system, and in this appears to differ from the beds in Canada and Newfoundland, which we suppose to be of corresponding age.

The writer is well aware that correspondence in the bulk or volume of measures in different countries, supposed to be coetaneous, is of uncertain value as a measure of time, but when, as in this case, it is checked at the upper limits by a well established faunal horizon, and at the base by a decided physical break, there being nothing in the constitution of the measures, or in the aspect of the known fauna, to suggest diversity of age, we are fairly justified in considering the measures contemporaneous.

Canada.		Newfoundland.	G. Britain.	Norway.	Sweden.
St. John Group (part) Division 1.	Band *d*.	Limestone of Chapel Arm in Trinity Bay.	Menevian Gr.	Etage 1 *d*.	Upper Paradoxides Beds.
	Do. *c*.	Shales of Manuel R.	Solva group part?	Part of Upper Sparagmite formation =Etage 1 *b* & *c*.	Lower Paradoxides Beds.
	Do. *b*...	?			
	Do. *a*..	?	Solva group part?	Part of Upper Sparagmite formation=Etage 1 *a*.	Fucoidal & Eophyton Sandstone.
Lower series of Cambrian System in Acadia.		Lower series members *a* to *e* of the Lower Silurian (*i.e.*, Cambrian) System.	Caerfai Gr.	Lower division of the Sparagmite formation.	?

Norway, Britain, Newfoundland and the eastern provinces of Canada afford unusual facilities for the study of these old Cambrian formations, and in the above table, an attempt has been made to co-relate these rocks from the information thus far gathered as to their mineral composition, stratigraphy and faunas:

The double cross line in the above table indicates the point at which a break in the succession of beds occurs in the Cambrian system in America.

It may be remarked that the lower series in Acadia, though unconformable to the St. John group, is closely related to it in its distribution.

Fauna of the Lower Series.

Hitherto we have been accustomed to look upon the assemblage of organisms found in Division 1. of the St. John group as the first link in the chain of palæozoic faunas in America, but investigations made during the last summer compel me to modify this view. That there were earlier forms of life in the measures at the base of the palæozoic systems, seemed probable for various reasons, and it had been asserted of the Intermediate system in Newfoundland, which Mr. Murray has classed with the Huronian, that in it two obscure forms did exist; but neither in Newfoundland nor on the continent of America, so far as the writer is aware, have any organisms been described from these basement beds of the Cambrian system proper.

Such being the very imperfect condition of our knowledge of the pre-Primordeal life of the Cambrian system in America, a very small addition to the information on the subject may be of value, and the few observations on the fauna made in New Brunswick are therefore presented here.

A barren sandstone, Band *a* of Division I, some two hundred feet in thickness, cuts off the fossiliferous horizons of the St. John group from all below; but as the Lower Cambrian series is now found to contain vestiges of organic life, down almost to the base, the fauna marked by Paradoxides may no longer be regarded as the oldest palæozoic fauna in America.

This lower series is lithologically very different from the St. John group, and in the eastern part of St. John county, and on the St. John R., exhibits a far more important series of beds than can be seen at the section in the city of St. John, where the Cambrian rocks were first studied. The older series has at its base a conglomerate, which rests in some places on the Coldbrook group, and in others on the Laurentian rocks. A good section may be observed at Hanford Brook, St. Martin's, where it presents the following succession (roughly estimated):—

	Estimated thickness in feet.
Coarse, purplish red conglomerate, resting on an a mygdaloidal greenstone (toadstone) of the Coldbrook Group	60
Grey flags and sandstones with worm casts (*Scolites*) and worm tracks (*Helminthites*). Alternations of grey and purplish red sandstones	70
Purplish, red sandstones, with greenish layers, remains of seaweeds (?) gritty, purplish red sandstones and flagstones, animal tracks *Psammichnites* and *Helminthites*, worm burrows (*Arenicolites*) and worm casts (*Scolites*)	240
Purplish conglomerate (35 feet) soft, purplish red shales, with green (glauconite ?) grains, the upper part firmer and more sandy; greenish, greylayers interspersed, especially toward the base. Remains of seaweed (?) and a brachiopod	210
5. Purplish, sandy shales, with a few bands of greenish shale. Worm casts (*Scolites*)	300
6. Measures concealed, probably of this series	320
	1,200

In this important series of beds, the very oldest layers, which are fine enough to preserve organic markings, abound with the trails and casts of marine worms, and within one hundred feet of these, in ascending through the measures, we meet with branching organisms in fine shale, which have left a thin carbonaceous film upon the layers of the shale; these impressions appear to have been seaweeds, but they may have been organisms allied to the graptolites or the sponges.

About three hundred and fifty feet above the base, where the measures are flaggy, tracks of annelids are again abundant. Beside the smaller trails and burrows, there are frequent tracks of a marine animal, similar to markings on the Fucoidal sandstones which by Prof. O. Torrell have been referred to the genus *Psammichnites;* and a very similar, if not identical track, occurs on the surfaces of the purple-streaked sandstones of Band *b* in Division 1. of the St. John group; this track is different from *Cruziana semiplicata*, Salt., and *C. similis*, Bill., which belong to a higher Cambrian horizon.

About fifty feet above this horizon occur fine shales, with a recurrence of the seaweed-like organism, and some ninety feet higher up, in a loose fragment of sandy shale, a very thin dorsal valve of a brachiopodous shell of considerable size was found; this shell is something like *Lingula monilifera* of the Eophyton sandstone, but is wider, has a less prominent beak, and the fine, radiating ridges on the surface do not exhibit a beaded crest. Some of the layers in this part of the series abound in soft, green grains, similar to the glauconite grains of the cretaceous and other formations, but the paste enveloping them is red.

A number of beds between this point and the uppermost measures exposed, contain worm casts and burrows, so that the entire series gives evidence of the existence in America of living forms during the whole of this introductory epoch of the Cambrian age, and encourages the hope that important additions will in time be made to our knowledge of the earliest forms of life of the Palæozoic ages.

Additional Species of the St. John Group.

Some interesting additions have also been made to the faunas of other Cambrian horizons. The measures on the St. John R., corresponding to those of Band *b* in Division 1 of the St. John Basin contain a calcareous organism, which may be referred to *Oldhamia;* it resembles *O. antiqua*, but branches less freely. In the same sandstone occurs an elegantly ornamented *Lingulella* (?) of peculiar form; it

may be compared to *Lingula* (?) *favosa* of the Eophyton sandstone, but is rounder, and the pitted surface occupies less space on the valve.

Division 2, of the St. John group has remains of several genera of seaweeds, among which are two graceful species related to *Taonurus* or *Spyrophyton*. In the same division are layers of fine grained shale, over whose surfaces are scattered fragments of the bodies of a small crustacean, with a very thin test; this is probably *Hymenocaris*, as the layers have frequent stiletto-like markings, such as the late Mr. J. W. Salter has attributed to this genus.

We now recognize four series of deposits in the Cambrian system of North Eastern North America, viz.: Series A, The Basal series, the subject of this paper; Series B, The St. John Group; Series C, The Georgian (Upper Taconic of Emmuns,) Series D, The Potsdam Sandstone. In a future article the writer proposes to show the grounds which exist for this quadripartite division of the Cambrian system in this part of America.

Proceedings of the American Association for the Advancement of Science for 1887.

By T. Wesley Mills, M.A., M.D.,

Professor of Physiology, McGill University, Montreal.

(*Read before the Montreal Natural History Society, October* 31.)

It is proposed in the present communication to give abstracts of a few of the papers read at the last meeting of the American Association, held in New York, and to make brief comments on some of them.

In the Geological Section, a communication on the action of glaciers gave rise to considerable discussion. Its author, Dr Spencer, had studied ice action in Norway, and his conclusions were, therefore, almost entirely the result of personal observations.

Professor Spencer believes that the eroding power of glaciers has been much over-estimated. He lays great stress on the plastic and flowing nature of glaciers; they do

not, in his opinion, push much material before them, but they carry enormous quantities of débris, derived from the sides of the ravines through which they pass, on their backs. The section did not seem to incline to Dr. Spencer's views, though I understand they have been more favorably received by Canadian geologists.

Anthropology.

As usual, the greater number of the papers read before the Section on Anthropology were archæological. Mr. Geo. F. Kunz exhibited two objects which attracted unusual attention. One of these was a gigantic jadeite votive adze, the other a marvelously beautiful crystal skull. The origin of both is such a mystery that an almost romantic interest was aroused by their exhibition and the two short descriptive papers relating to them, read by Mr. George F. Kunz. He declared the adze to be of Mexican origin, and said it was the largest votive adze yet found. It was discovered twenty years ago in Oaxaca, Mexico. It is 10 13-16 inches long, 6 inches wide, and 4⅝ inches thick, tapering off to a blunt edge. The color is a light grayish green, with streaks of an almost emerald green on its back. Originally almost wedge-shaped, out of one side the features of a deity have been carved. These are decidedly of Mongolian physiognomy. The lapidarian work is probably equal to anything that has ever been found, and the polish is as fine as any produced by modern man. When the exceeding hardness of the stone is taken into consideration, resisting as it does the action of edged tools, the mystery regarding its production is deepened. The only explanation suggested was that the shaping of the stone had been accomplished by long-continued, patient scouring with sand. In reply to inquiries regarding any possible legends connected with the stone, it was said that the only one which deserved consideration was that the emerald-hued deity was originally of India, where it had been the object of worship, and that either away back in the mysterious ages of antiquity, when the Asiatic migration to America took place, it had been

carried along by the tribe whose god it was, or else some casual refugee from the Orient had found his way with it in equally mysterious fashion to the western world.

After the adze had been exhibited and compared with certain uncarved adzes of jade of inferior size and beauty, Mr. Kunz produced a curious cabinet, made of the skin of a Mexican lizard, which, when opened, revealed a skull of nearly natural size and almost transparent. It was carved of crystal, without flaw or fissure. It was discovered by a Mexican officer just before the Maximilian conquest, and sold to Mr. Evans, the English collector, at whose death it passed into the hands of a French dealer in curiosities, of whom it was purchased by Mr. George H. Sisson, of New York. As to its origin, little or nothing more is known. Crystal of the same character is found in Calaveras County, Cal. Although similar in general appearance to many of the Chinese and Japanese crystals, it was clearly not of Chinese or Japanese origin, or nature would have been more closely copied. And on the other hand, if it were of European origin, it would have been more carefully finished in certain minor particulars. In the Californian locality, large masses of crystal have been found, and from the State of Michoacan, Valley of Mexico, small skulls of this same material, measuring rarely more than two inches across, have often been brought, indicating that the ancient Mexicans were acquainted with a means of carving and polishing, not inferior in results to the best modern inventions. The skull is 8 3-16 inches long, 5⅜ inches wide, and 5 11-16 inches high. The eyes are conical hollows about 1½ inches deep. The line separating the upper and lower teeth is thought to have been produced by a string or bow.

Palin Baba, the Japanese, gave some reasons why the remarkable skull could not be considered of Japanese or Chinese origin, the substance of which was that it was not sufficiently true to nature in contour.

Dr. Charles Porter Hart read a paper on "The Correlation of Certain Mental and Bodily Conditions in Man." He said his attention was first called to the subject by a patient who possessed such decided pessimistic views as to

interest him. He was suffering from an abdominal disease which seemed to produce mental aberration. Upon every topic that could be suggested—social, governmental and religious—this gentleman was fearfully pessimistic. Dr. Hart gave a table showing that diseases above the diaphragm were optimistic in their tendencies, those below the diaphragm, pessimistic, and those of a constitutional and chronic character, such as rheumatism, malaria and dropsy, were equally pessimistic and optimistic. Chest diseases gave buoyancy to the system, and abdominal diseases were very depressing.

Dr. Hart offered no explanation whatever of these statements, which in themselves the experience of general medical practice will bear out. I would suggest that the large capacity of the blood vessels of the abdominal region; the tendency to stagnation in the veins; the great variations in the calibre of the arteries, effected through the nervous system; the abundant supply of nerves to the organs, and their connection with both spinal cord and brain; the partial starvation consequent on disease of certain organs below the diaphragm, and many other influences, which might be enumerated, will account fairly well for the relation of the physical to the bodily conditions noticed. And it must be remembered that lung diseases may run an almost painless course; but that with most abdominal maladies there is more or less of obscure irritation, if not actual pain, which must tend to exhaust the nervous centres, and, in consequence, to be followed by mental depression.

Dr. Jastrow's paper on "Modes of Apperception," which presents some aspects of truth of great practical importance, and with very direct bearings on methods of teaching. The author of this communication maintains that individuals may be roughly classified as "visualaires" or "auditaires," according as they perceive and remember better by the use of the eye or the ear. Certain tests have been proposed with a view of affording a means of classifying persons,—such as reading aloud a paragraph from some book and comparing the results, in the case of those ex-

amined, with similar results obtained by asking each individual to read the paragraph over silently. Those who would, other things being equal, remember the contents best when read to them, are natural "auditaires." That the author's views are in the main correct, I believe, the more so, perhaps, from being myself a pronounced auditaire; and in every instance in which I have unconsciously failed to recognize this, have I had reason to regret the oversight. The majority of persons are probably "visualaires." The modern method of teaching English spelling in our schools, seems to be an unconscious recognition of this fact. But it will be found that there are children who will learn spelling as readily by the old method of repeating the component letters aloud, as by the use of the eye and the hand. The latter must not be forgotten in the estimate. The subject is one of great interest, and commends itself strongly to teachers and parents.

Perhaps no papers read at the meeting attracted more general attention than those bearing on foods, as presented before the sections of Chemistry and Economic Science.

Instead of giving a little time to each of many subjects, as was the rule with the other sections, the section on Economic Science and Statistics devoted the whole of one day to two papers by Prof. W. O. Atwater, bearing upon the food question. The morning paper was upon "The Physiological and Pecuniary Economy of Food;" that of the afternoon upon "The Food of Workingmen and its Relation to Work Done." Both excited much interest, and were received with demonstrations of satisfaction by large audiences, many taking part in the discussions which followed. Prof. Atwater, whose papers have been published in the *Century*, illustrated his subject by many elaborate charts and diagrams.

Explaining, first, the elements of the common foods that combine to form the structure of the human system, and to supply it with potential energy, he indicated the quantity of each of the nutrients consumed by people in various walks of life in Europe, and compared them with the averages of the same entering into the composition of the

American diet. From this it appeared that the American consumed considerably above the standard of necessity, and wasted a great deal more, while the European rarely excelled the standard, and frequently fell below it. Among the working classes of Europe, the sewing girls of London and the factory girls of Leipsic were poorest fed, while the brewers were best fed. In America, all classes of working people consumed far more than was necessary for the maintenance of health and strength.

Under the term "Nutrients," he classed protein (the lean of meat, white of eggs, casein of milk, gluten of wheat, etc.,) which supply blood, muscle, tendon, and bones; fats, animal and vegetable, which serve as fuel for the body; carbo-hydrates, starch, and sugar, which also make fat and supply the body with heat. The nutrients of vegetable food are much less costly than those of animal foods, but the latter have the advantage of containing large proportions of protein in more digestible forms. At market prices current in the Eastern States, the cost of protein, which may be taken as a measure of the relative expensiveness, ranges from 8 to 34 cents per pound in staple foods, and from 18 cents to over $1 a pound in staple animal foods. In oysters it is from $2 to over $3 per pound, while in salmon it rises to over $5 a pound. In beef, at from 10 to 25 cents a pound, the protein ranges from about 40 cents to $1.10. In such fish as shad, bluefish, halibut, mackerel, lake trout, and whitefish, the nutritive material costs more. The less expensive kinds of meat, such as the shoulder and the round of beef and ham, contain as much nutriment as the costlier kinds, and the difference palatably is more the result of the manner of cooking than of any innate superiority in the higher priced cuts. So, too, the different grades of flour have a much more nearly equal nutritive value than is commonly supposed. Wheat flour, cornmeal, oatmeal, and other cereal products are in general, cheaper and richer in nutrients than potatoes and other roots. Taking the world throughout, the mass of mankind selects foods which analysis shows to furnish actual nutrients at the lowest cost. But the people of the United

States are a marked exception. Many, even among those who really desire to economize, use needlessly expensive kinds of food. They endeavor to make their diet attractive by paying high prices rather than by skillfully cooking and tastefully serving. Then, too, they are more wasteful than any other nation. An inexplicable sensitiveness upon this point exists among American workmen. The best the market affords alone is good enough for them, and by their constant demand for what they wrongly consider the choice cuts of meat, they maintain the present high prices. Improper eating, especially over-eating, is a source of disease more than any other one thing; the eating habit does more harm to health than even the drinking habit. The remedy lies in persuading people that economy is respectable, and in teaching them how to economize.

Prof. William H. Brewer, of New Haven, regretted that the lecturer had not recommended the forms of food to be substituted for more expensive ones of no more nutritive power. He believed that foods rich in protein and carbohydrates had not only a more beneficial effect upon the physical conditions of the people, but exerted beneficial influences as well over their morals.

Prof. Ordway, of New Orleans, thought Americans did not really consume so much more than Europeans as the lecturer inferred. Waste mostly explained the apparent difference.

At the Afternoon Session, the hall was again filled with an audience which appreciated the importance of the discussion, though some of them did not agree with the lecturer's propositions. "Statistics of dietaries of considerable numbers of Americans," said Prof. Atwater, "mostly of the working classes, show that their food is large in amount, and includes large proportions of meat. French-Canadians at home, consume three and a half pounds of food per day. On going to Massachusetts factories, their quantity of food is increased to five pounds. Other American factory operatives, mechanics, and laboring people, native and foreign, averaged a little more—in some cases seven pounds. Chemical examination of the dietaries,

showed them to be richer in actual nutritive material and in potential energy, than even the large quantities would imply, on account of large proportions of meat. The quanties per day, of protein, ranged from 95 grams in the case of a Massachusetts glass-blower, to 254 grams in that of teamsters, marble workers, and other laborers, in a Boston boarding-house. German standards call for from 118 to 145 grams in the daily food of a laboring man, according to the severity of his labor. The proportions of fat varied from 109 grams in food of French Canadians at home, to over 360 grams in that of the Boston boarding-house referred to. The German standards include from 50 to 100 grams of fat. As the German standard represents the actual quantity consumed by well-to-do mechanics, and reliable data imply that laborers in France, Italy, and other countries of Europe, consume about the same quantities, it appears that the food of the American laboring man is much more nutritious on the average than that of his European competitors. As one result, the American workingman turns off much more work than the European. The American workman is better paid, better housed, better clothed, and better fed than the European. He has better opportunities for self-development, more to stimulate his ambition, and more hope of reward if his work is efficient. He accomplishes a great deal more. These factors are all connected, but the explanation of his superior capacity for work is to be found largely in his superior nourishment. What ought to be the panurgy of the American workingman, with his great opportunities, his superior intelligence, and the 6,776 foot-tons of potential energy in his daily food?"

Some 12 or 14 members availed themselves of the oppor tunity presented to criticise and comment upon the propositions advanced. Mrs. Richards, of Boston, Mass., gave a description of the cooking schools in that State. They found that such knowledge was best inculcated when the girls were from 12 to 14 years of age. These lessons frequently resulted in such changes of cooking in the homes of the girls, as manifested beneficial results in the manners, dispositions, and morals of the family. She advocated

industrial cooking schools in connection with the public schools.

Prof. E. J. James, of the University of Pennsylvania, thought the question of economy in food supply of fundamental importance to the welfare of the country. It was extremely unfortunate, he said, that some writers have accompanied their statements with remarks that have made the working classes suspect that cheap food means low wages,and that expensive diet means high wages. It does not. This is at bottom, a social question, and if it is not wisely treated, the result of advance in science may redound to the benefit of the few and possible detriment to the many, Every new food added to the list of those regularly consumed. tends to diminish the demand for the staple article, and, consequently, tends to lessen the cost of living.

Taking all Professor Atwater's papers together, as published in consecutive numbers of the *Century*, I gather that his views are broader than might seem from the above account; viewing the papers, however, as read at the Association meeting, they suggest to me a number of considerations worthy of more attention than I shall be able to give them on this occasion. One thing seems clear—that the food question, like so many others, is complicated by false views as to the meaning and purpose of human existence. People spend money for what is not bread, in both a literal and a figurative sense. The American workman wishes to appear, according to these witnesses, "better off" than he is.

Mrs. Richards' remarks are full of suggestiveness. Even from the discussion before the Association, it becomes very plain that the food question has other aspects than the economic, the chemical or the physiological. To say, as Prof. E. J. James does, that "this is at bottom a social question," is placing it on far too narrow a basis. Not to go beyond the papers and the discussion evoked, it appears that the subject has chemical, physiological, economic and moral aspects, at least. The ill-fed and the over-fed human being are alike liable, not only to physical, but to mental and moral disturbance. If the relations between mind and

body are constant and absolutely dependent on fixed, though but partially known laws, it should be one of the aims of science to show more clearly what these laws are; and in this all the specialties may combine with a noble end in view.

In estimating the diet that is best, many considerations beside the chemical composition of the food, the action of the digestive juices, etc., must be taken into account. A food that is capable of maintaining one individual at his maximum of energy is not such for another; and this may depend on subtle influences of race, habit, occupation, and countless factors of the past and present, which neither chemist nor physiologist can estimate, except in the roughest and most general way. Fortunate it is that our instincts are wiser than ourselves—our conscious, scientific selves. Such considerations should not tend to lessen our estimation of the value of such work as the chemist, the physiologist, the anthropologist, the psychologist and others can do. It all has its place, but we must beware of drawing conclusions too hastily or making generalizations that are too wide.

Specialism, with its limited fields, its more elaborate methods and its minute details, is necessary to the advance of science. But the dangers are great, as the subject under consideration well illustrates. One of the questions of the day to not a few minds is: How may specialism exist so as to subserve the ends of science and not lead to narrow, and consequently erroneous, views? It is doubtful whether it is not better to have no definite conceptions of a subject than highly distorted ones. It is true, the critical spirit of the day tends to sift all views and errors are being constantly exposed; they may, however, be speedily replaced by another crop. The remedies or rather the means of preventing, at least in part, this state of things, it appears to me, are:—

(1) A sound and broad education on the part of the individual who proposes to specialize.

(2) Joint work—many different specialists attacking the problem from different points of view and comparing

results. In large laboratories this could be done. Such treatment of subjects as that given the food question by the American Association is highly suggestive.

(3) Attendance of specialists at societies where diverse topics, not of exclusive interest to any one specialty, are discussed. I think the occasional delivery of a popular lecture helps not a little to correct the specialist's natural tendencies to aberrations of one kind and another. His attention is thus turned to substantial results rather than to methods of work.

THE PRAIRIES OF MANITOBA.

BY A. T. DRUMMOND.

In August of this year, another opportunity occurred to me of examining the superficial deposits around Portage la Prairie, Birtle and Kinbrae—the last named place about thirty miles north-west of Fort Ellice. The resulting facts will prove of interest in connection with questions that have been discussed about the origin of the north-west prairies.

At Portage la Prairie the country is on all sides flat, and bears evidence of two to three periods of growth and decay of grasses and reeds in shallow water, alternating with periods of subsidence of the land. The general surface is perhaps twelve feet above the Assiniboine River, and that stream is in turn about the same number of feet higher than Lake Manitoba, which lies only fourteen miles to the northward. The banks of the river, in a height of twelve feet, show three layers of black loam, each from six to twelve inches or more in thickness, alternating with a creamy gray clay, and the whole underlaid near the water's edge by a reddish clay. Boulders throughout this section of the country and eastward to Winnipeg are unseen, even in the bed of the river at low water. Towards Westbourne, the large tract of low land, usually covered with water, and lying between Rat Creek and the Westbourne marsh proper, and through which the Manitoba and Northwestern Rail-

way's track is built, was perfectly dry. That this was an exceptionally dry year, was shown by the enormous numbers of dead shells of *Limnæa*, *Planorbis*, *Physa* and other genera, which, everywhere, rendered the ground crisp under the tread of the foot. The ground was covered by a heavy growth of grasses of three or four species, scattered everywhere in great patches, each grass occupying its own patches to the exclusion of the other grasses. The soil is a heavy black loam, and the surrounding circumstances all clearly show how such soils have been formed in the valleys of the Lower Assiniboine and of the Red River, and around Lake Manitoba, by the annual decay of such marsh grasses.

To the westward of the Big Grass Marsh and the Westbourne Marsh, circumstances are changed. The country, after leaving the gravel ridges which strike the line of the Manitoba and Northwestern Railway at Arden, becomes of a slightly rolling character, and increasingly so some distance farther westward. As Neepawa is approached, the surface loam is underlaid by sand. Boulders become exposed in the river valley at Minnedosa and in the side valleys leading into it—washed out, no doubt, from the drift clays which at a greater or less depth underlie the surface soil. At Birtle, the Laurentian boulders are not only common in tbe deep valleys, especially on the eastern side, of the Bird Tail and of Snake Creek,—appearing in almost a solid mass of both large and small boulders at one point at the creek level near Birtle—but are also on the surface of the prairie above. They are in the latter case, generally more common in and upon the surface of the low ridges which heré and there somewhat parallel each other. Proceeding still westward, boulders are not frequent in the valley of the Assiniboine River at Fort Ellice and at the railway crossing eighteen miles up the stream, but the bed of the river at the ford is formed entirely of very large sized gravel. Nor do boulders appear again until the country beyond Langenburg is reached. Here there are two or three gravelly knolls rising twenty-five or thirty feet above the general level, like the Spy Hills, also gravelly knolls,

nearer Fort Ellice. In the vicinity of Kinbrae, the surface soil is a sandy loam with ridges of loam mixed with gravel. A well sunk here on George B. Fisher's farm, gave a section showing in descending order, one foot of sandy loam, eleven feet of clay, with a few rounded boulders in it, and thirty feet of sand, which grew coarser towards the bottom. At Langenburg, another well gave, before the sand was reached, one hundred and sixty feet of wet sticky clay, holding boulders. There was considerable difficulty in securing water at this latter place until this depth was reached. At neither place was there any appearance of layers of black loam as at Portage la Prairie and Winnipeg. The boulders here and at Birtle are relatively small, seldom exceeding two feet across, and, with the gravel, have rather the worn appearance resulting from the action of ice than the rounded look which the water on a sea or lake coast would give them. Both boulders and gravel in the neighborhood of Kinbrae are Laurentian, intermixed with some of a limestone which weathers a buff in colour. One of these larger limestone boulders was heavily striated and was, otherwise, worn smooth to the condition of a slab. Nearly all of the sloughs were dry, as a result of the drought this year, and some were, like the dry marshes near Westbourne already alluded to, dotted with the dead shells of *Limnæa* and other fresh water mollusks.

CONCLUSIONS.

The conclusions I have formed are, that the Manitoba prairies east of the Pembina and Riding mountains are the most recently formed, and are still undergoing a process of extension in the great marshes still existing and on the shallow lake margins, through the annual growth and decay of the luxuriant grasses growing there. There had been two or three depressions of the land in the course of the formation of these prairies, during each of which, deposits of sediment, carried down by the muddy northern and western rivers, were made over the loam formed by such decaying grasses, giving thus the alternate loam and clay now observable. There is no evidence to show that

during these depressions the subsidence was sufficient for, or the other surrounding conditions favourable to, the action or even the existence of icebergs, though previous to this time, this section of the Northwest was no doubt also subject to the action of ice, all evidence being now covered up by the more recent deposits here referred to.

West of these lower and more recently formed prairies, are the rolling prairies, which have an origin somewhat different. The stretches of sand, both on the surface and under the clays, point to the existence of extended lake and sea margins at more than one period. The extensive, somewhat parallel gravel ridges at Arden, the gravel knolls, the smaller ridges with boulders in and on them at Birtle and west of Langenburg, and the uneven, rolling nature of the surface of the prairie, all seem to me to point to the action of icebergs in the glacial or post-glacial seas, modified afterwards by the water during subsidence, and to indicate the direction of the force, whether wind or current or glacier, which at these places impelled the bergs onward. Further, the thinner surface loam, mixed to the westward with some sand, would seem to point to a condition of growth and decay of plant life, less defined than and probably of a different character from that on the lower prairies to the eastward.

The Assiniboine, though presently a branch of the Red River, was not always so, and is in its upper reaches above Brandon, a much older river. When the whole prairie east of the Riding and Pembina Mountains was a vast shallow lake, the Assiniboine was a large stream varying from half a mile to a mile and more in width for most of its course, discharging into this lake the surplus waters of the country to the northward and westward. As the whole surface of the continent here, to the east and west, but more especially to the westward, continued to rise, in the long lapse of time, the Assiniboine, with the strongly increased current which its relatively higher level westward gave it, cut its way through the surface soils to its present great depth of about two hundred feet below the prairie level.

As the land eastward of Brandon rose above the water level, the river had of necessity to form a continuation of its course to some new outlet for its waters. This new outlet was eventually found at Winnipeg, where it joined the Red River, which must then have been a new stream, formed by the waters of the south, seeking, by reason of the rise of the land there, a new exit to the sea to the northward. That the Assiniboine had by this time become a small stream compared with its former proportions, is shown by the contracted banks of this newer part of its course, those at Winnipeg and Portage la Prairie being not more than from two to three hundred feet apart, and from twelve to fifteen feet high.

Note on a Specimen of Lake Iron Ore from Lac la Tortue, P. Q.

By B. J. HARRINGTON.

Some time ago, through the kindness of Mr. George McDougall, of Three Rivers, P. Q., the writer was enabled to obtain a specimen ot Lake Iron Ore from the bottom of Lac la Tortue, where the material is said to occur in considerable quantity. The Lake is situated about twenty miles north of Three Rivers in a region which, according to Sir William Logan's geological map, is occupied or underlaid by rocks of Laurentian age. In appearance, the ore closely resembles one of the concretionary bog ores found in so many parts of the country, and of which analyses have frequently been published. A few months ago, an analysis of the La Tortue lake ore was made by Mr. W. A. Carlyle, B. A. Sc., then a student in the laboratory of McGill College, and the results are deemed worthy of recording, especially as no facts concerning Canadian lake ores have hitherto been published. No. I. is Mr. Carlyle's analysis, while No. II. is one by Svanberg of a Swedish lake ore:—

Ferric oxide....	69.64	69.95
Ferrous oxide...............	0.72	....
Manganic oxide ($Mn_2 O_3$).....	2.99	1.97
Alumina	2.43	3.47
Lime.........................	....	1.82
Magnesia.....................	0.60	0.06
Phosphoric anhydride.......	0.47	0.56
Sulphuric anhydride	0.09	0.12
Silica........................	8.17	5.85
Loss on ignition.............	15.00	16.19
	100.11	99.99
Metallic iron................	49.31	48.96
Phosphorus......	0.205	0.244
Sulphur......................	0.036	0.048

It will be observed that the correspondence between the two analyses is very striking, and also that in a general way, these lake ores resemble our ordinary bog ores in composition. Judging from published analyses, however, the average proportion of volatile matter in the latter is higher than in the lake ores. The average quantity of water, deduced from nine analyses of Canadian bog ores, is 19.78 per cent., while the average deduced from seven analyses of Swedish lake ores by Svanberg, is only 14.13 per cent. (*)

ROCEEDINGS OF NATURAL HISTORY SOCIETY.

SESSION 1887–1888.

The First Monthly Meeting of the Society was held on Monday evening, October 31st, 1887, at eight o'clock.

The minutes of the last meeting were read and confirmed, also the minutes of Council Meetings, June 9th, September 20th, October 24th and 31st.

The Honorary Curator reported the following donations to the Society. A collection, composed of native spears, clubs, dresses, mats, shells, stones, etc., from the Samoan

(*) For Svanberg's analyses and other particulars concerning the Swedish lake ores, see Percy's " Metallurgy of Iron and Steel."

Islands, bequeathed by the late Mr. George J. Bowles, presented by his son, Mr. George Bowles.

Specimen of *Vulpes lagopus* (Arctic Fox), by an unknown donor; Nest of Common Black Wasp (*Vespa maculata*) from Mr. W. G. Oswald, Belle de Revière, Two Mountains; Specimens *Belosoma americana*; Busts of Bishop Fulford and his father, from Mr. Charles Holland.

Dr. T. Wesley Mills then read a very interesting paper on "The Meeting of the American Association for the Advancement of Science, for 1877," a *resumé* of which appears in this number of the Record.

The Second Monthly Meeting was held 28th Nov., 1887, at eight o'clock. Sir Wm. Dawson in the chair.

The minutes of the last meeting were read and confirmed; the minutes of the last Council meeting were also read.

In the absence of the Hon. Curator, the Hon. Librarian reported a donation from Mr. Montpetit of an *Astrophyton vermicosum*, "Star of the Sea," from Labrador, for which the thanks of the Society were expressed.

The following gentlemen were elected: Walter Drake, Dr. Ruttan, Hon. Justice Baby, as ordinary members, and Rev. Dr. W. E. Winslow, of Boston, and Dr. D. B. McCartee, Amoy, China, as Corresponding Members.

A letter was read from Dr. L. N. Britton, Treasurer of the Audobon Memorial Fund, soliciting subscriptions, which was referred to the Hon. Treasurer.

Mr. A. T. Drummond read two very interesting papers, "The Prairies of Manitoba, and "The Physical and Past Geological relations of British North American Plants," which created considerable discussion.

These papers appear in the present issue of the Record.

Montreal Microscopical Society, Session 1886-87

The annual meeting was held on Monday evening, October 18th, 1886, in the library of the Natural History Society.

The following officers were elected for the session 1886-87:—

President—Very Rev. Dean Carmichael.

Vice-President—D. P. Penhallow, B. Sc., F.R.S.C.

Treasurer—A. Holden.

Secretary—Jeffrey H. Burland.

The second monthly meeting was held on Monday evening, November 15th.

After the regular business had been attended to, the President read a very interesting paper, entitled, "Rules for Distinguishing Animal from Vegetable Organisms." The Treasurer was elected Secretary-Treasurer, Mr. Burland having resigned as Secretary.

The third monthly meeting was held on Monday evening, December 13th, in the laboratory of Dr. J. B. McConnell, when he read a paper on "Bacteriological Methods," bringing before the society, in the most lucid manner, a general outline of the action of bacteria and the modes of sterilizing, propagating and detecting them.

The fourth monthly meeting was held on Monday evening, January 10th, 1887.

Mr. J. Stevenson Brown gave a demonstration on modes of mounting objects for the microscope, showing some very ingenious apparatus made by himself, which was most instructive and highly appreciated.

The fifth monthly meeting was held on Monday evening, February 14th, 1887.

The Secretary reported that in response to the invitation of the Natural History Society to attend the Conversazione held at the Museum on the 20th January, twenty members of the society were present, with their microscopes and objects, and were assisted by friends from the McGill University and others.

Mr. A. W. Clement read a very interesting paper, "The Use of the Microscope in the Inspection of Meat," illustrating same by appropriate slides.

The sixth monthly meeting was held on Monday evening, March 14th.

The paper of the evening, by the Rev. Dr. Smyth, "Chalk as seen through the Microscope," was well illustrated with drawings and slides.

The seventh monthly meeting was held on Monday evening, April 18th.

Dr. Wanless' paper, "The Determination and Results of Minute Materials, Physiologically and Microscopically Considered," was illustrated with interesting experiments and slides.

The eighth monthly meeting, held on Monday evening. May 9th, after the regular business, was devoted to the exhibition by the members of diatom slides.

Session 1887-1888.

The annual meeting of the society was held on Monday evening, October 10th 1887.

The following officers were elected for the session 1887-88.

President—Professor D. P. Penhallow.

Vice-President—J. Stevenson Brown.

Secretary-Treasurer.—A. Holden.

The annual reports were read and adopted.

The second monthly meeting was held on Monday evening, November 14th.

The President read a most interesting and instructive paper, "The Microscope as an Aid to Research," exhibiting some very fine objectives, and other accessories.

MISCELLANEOUS.

We have recently received the last published statement of the valuable series of investigations conducted by Sir J. B. Lawes at Rothamsted, England. This statement was first formulated in 1877 for the occasion of the twenty-fifth anniversary of the establishment of the First Experiment Station in Germany, at Mökern. Since then it has been continued each year, and extended to embody the more recent work of the field and laboratory. From the number before us, we find that from 1847 to 1887 the published results of the work conducted during this period by Sir J. B. Lawes and his staff of assistants, number no less than one hundred and four. As most of our readers are aware, these publications embody some of most important scientific results touching the chemistry of plant foods and their sources in the soil. Probably no experiment station has done more in the way of securing valuable and accurate scientific data, to advance the cause of scientific agricultnre, than Rothamsted.

The experiments at Rothamsted began in 1834 with a simple series of pot cultures, designed to throw light upon the relation of various chemical compounds to vegetable nutrition. These rapidly led to more enlarged operations in the field, supplemented by laborious researches in the laboratory by some of the most eminent chemists and botanists of the day. There was thus developed a systematic method of enquiry, which has resulted in throwing much important light upon many obscure or imperfectly understood laws. The peculiar value of the system adopted may be fully appreciated when we state that some of the experiments have been extended continuously for thirty-seven years, and are likely to be continued into the future for an indefinite period.

Although this valuable work is conducted primarily with reference to the practical application of the results, it has led to the accumulation of a large amount of data which are of the highest value from the standpoint of pure science. Very few institutions of a similar character have been able to surpass Rothamsted in the character, extent and general usefulness of its work. That the institution has a liberal endowment and is established on a broad scientific basis, reflects the highest credit upon its founder.

Unfortunately, many of the valuable papers embodying these results are no longer to be obtained. The annual statement, therefore, serves as an important means of gaining a summary of some of the more extended investigations and as a valuable historical and bibliographical record.

NOTICES.

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AND REPLACING

THE CANADIAN NATURALIST.

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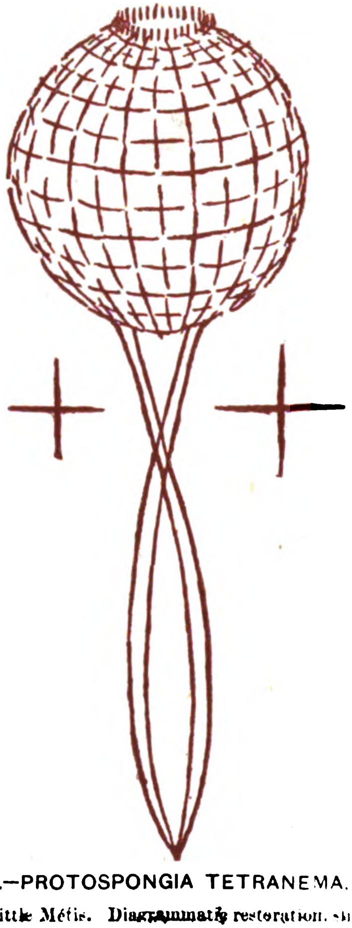

FIG. 1.—PROTOSPONGIA TETRANEMA. S.N.

Quebec group, Little Métis. Diagrammatic restoration, slightly enlarged.

THE

CANADIAN RECORD

OF SCIENCE.

VOL. III. APRIL, 1888. NO. 2.

PRELIMINARY NOTE ON NEW SPECIES OF SPONGES FROM THE QUEBEC GROUP AT LITTLE MÉTIS.

BY SIR J. WILLIAM DAWSON, LL.D., F.R.S.

Little Métis Bay presents a good section of rocks of the Quebec Group, including sandstones, slates and conglomerates similar to those which characterise this series of beds along the south shore of the St. Lawrence. These beds have afforded a species of *Retiolites*, allied to or identical with *R. ensiformis* of Hall[1], worm-burrows of various forms, including a spiral form similar to *Arenicolites spiralis*, and radiating markings of the kind elsewhere known as *Astropolithon*. A small species of *Obolella* also occurs, resembling *O. Ida* of Billings. In the conglomerates are limestone boulders, holding fragments of Trilobites of the genus *Solenopleura* and other fossils; but these seem to be of Middle Cambrian age, or considerably older than the beds in which they occur.

There can be no doubt, from the stratigraphical position

[1] Identified by Prof. Lapworth.

of these beds, that they belong to the Quebec Group of Sir W. E. Logan. This is, however, now known to include, on the Lower St. Lawrence, beds ranging from the Calciferous to the Trenton, and the beds are so much plicated that it is often difficult to unravel their complexities of arrangement.[1] At Métis, the evidence of the pebbles in the conglomerates indicates that they are newer than the Middle Cambrian, and the few fossils found in the sandstones and shales would tend to place them at or near the base of the Lévis division, or approximately on the horizon of the Chazy, or equivalent to the English Arenig. Lapworth, in his paper on "Canadian Graptolites," suggests that the sandstones holding Retiolites are older than this; but hitherto we have not found at Métis the characteristic Graptolites of the older or Matane series, which occurs further east, and is probably of Calciferous or Tremadoc age.

In the past summer, Dr. Harrington, F.G.S., was so fortunate as to find a bed of black shale rich in remains of sponges, hitherto unknown in these rocks, and having made known the fact to the writer, we visited the place several times and made considerable collections of these interesting fossils, which are now in the Peter Redpath Museum.

The locality of this discovery is the beach at the foot of the cliff below the Wesleyan church, where a considerable thickness of black shales appears well exposed. The section at this place is as follows, in descending order:—

1. A thick bed of hard sandstone or quartzite and conglomerate, forming the cliff immediately in front of the church, and shewing in some of the beds radiating markings (*Astropolithon*).

2. Black and dark gray shales, with a few calcareous bands—thickness about 100 feet. The black shales of this band hold sponges and layers of sponge spicules, with fucoids (*Buthotrephis*, of a new species,) and valves of a small *Obolella*. All of these fossils are usually in a pyritised state.

[1] Logan, Geology of Canada, 1863; Selwyn, Report Geol. Survey, 1877-78; Ells, *Ibid*, 1880-82; Lapworth, Canadian Graptolites, Trans. R. S. C., 1886.

3. Flaggy sandstone and shale, about 20 feet.

4. Hard sandstone with quartz veins, 3 to 5 feet.

5. Hard gray shales and calcareous and dolomitic bands, with some layers sf sandstone—800 feet or more.

6. Apparently underlying these, and occupying a great extent of the shore, are black, gray and red shales and thick beds of gray sandstone, the latter appearing at Mt. Misery and Lighthouse Point, and holding the Graptolites above referred to. These beds must be of great thickness in the aggregate, but they are possibly repeated in part by faults and contortions.

The sponges contained in Band 2 above, are apparently confined to a small thickness of the shale, but in this are quite abundant. They are perfectly flattened, and their spicules are replaced by pyrite; but in some cases they retain the outline of their form, and have their root spicules attached. The spicules were, no doubt, originally siliceous, but they have shared the chemical change experienced by other fossils in this bed, whereby they have lost their siliceous matter and have had pyrite deposited in its place. In some cases, also, the pyritised spicules have been frosted with minute crystals of the same substance, greatly enlarging their size and giving them a mossy appearance. This pyritization of spicules, once probably silicious, is not uncommon in palæozoic rocks, and it arises from the soluble condition of the silica in sponges, and its association with organic matter, which, in some modern sponges, as in Hyalonema, enters into the composition of the spicule itself. These spicules, therefore, suffer the same change with the calcareous shells associated with them.

Many of the sponges in these beds have been entire when entombed. Others are decayed and partially broken up, and there are some surfaces covered with confused patches of loose spicules arising from the disintegration of many specimens.

Some remarks are perhaps necessary here respecting the appearance of sponges in different states of preservation. Of course the original textures of sponges are different, and

those which have consolidated spicules or firm external cortex, are those most likely to retain their original forms. Even the looser kinds of sponges, however, may under certain circumstances preserve their rotundity of form, in which case they will usually show external markings, but not so well internal structure, unless when sliced. On the other hand, when completely flattened, which is usually the case in shaly beds, only an outline of the form remains, and sometimes not even this, while the forms and in part the arrangement of the spicules are usually apparent. Farther, the hollow and thin-walled species are more liable to be completely flattened, though in some cases, as in the Devonian Dictyospongiæ, they may retain their form. It was this property, and the membranous appearance of the outer coat, that for a long time sustained the belief that these were plants rather than sponges.

In the case of the sponges procured in the shales at Little Metis, perfect flattening has occurred, and in many cases the spicules have been separated, and appear as mere spicular patches or layers. In other instances, however, they remain approximately in their natural position, and even the general outline of the form can be observed. The collections include several species of sponges, Hexactinellid and Monactinellid; but, so far as observed, one of them is more abundant and better preserved than the others. The following may serve as a preliminary rough description of the species collected,—which will be more fully described and commented on by Dr. J. George Hinde, F.G.S., the author of the British Museum Catalogue of Fossil Sponges. See paper appended.

1. *Protospongia tetranema.* S. N. (Fig. 1)[1] The general form has been spheroidal, probably with an osculum or oscula at top. Root composed of four long spicules in two pairs, which diverge somewhat and then bend toward each

[1] This figure is a restoration, with two of the spicules enlarged. The defensive spicules and osculum are conjectural, being based merely on loose spicules and general form.

other and unite, forming a loop. General diameter, about 3 to 5 centimetres. Length of root-spicules, 6 to 7 centimetres, Wall of body apparently thin, composed of large cruciform spicules, stout at centre and tapering to sharp points, and arranged in square meshes, with smaller spicules of the same forms in the meshes. Length of largest spicules and size of meshes, 1 centimetre or less.

The structure of this sponge places it in Protospongia of Salter. It is true that the species of Protospongia are not known to have root spicules, but these must have been present in some form, and perhaps the bundle of spicules from the Menevian, described by Hicks as *P. flabella*,[1] may have been of this nature.

The root of this species is very peculiar in its arrangement. It seems to have been a cruciform spicule, of which the rays were bent upward and lengthened, forming a stalk for the sponge. This would give a firm attachment, and adapt itself to the gradual rise of the bottom to which the sponge was attached. The mechanical properties of such an arrangement of spicula are obviously well suited to effect their purpose.

Salter, in his original description of *Protospongia* from the Cambrian of Wales, compares it with *Acanthospongia* of Griffiths from the Silurian of Ireland, the original specimen of which he had seen; but says it has six-radiate spicules. He also remarks that the spicules of Protospongia seem to be all on one plane.[2] *P. Major* of Hicks is a still older species from the Lower Cambrian or Longmynd Series, and seemingly of different structure and of much more open texture than that above described. Matthew has also noticed and figured fragments of Protospongia from the Lower Cambrian of St. John, New Brunswick. The present species, though somewhat later in age than the foregoing, has the merit of presenting a better state of preservation and better illustrating the general form, and more especially the root-spicules.

[1] Hicks' Jour. Geol. Soc., Vol. xxvii.
[2] Journal Geol. Soc., Vol. xx.

2. A second species shows numerous large and long root spicules similar to those included in the genus *Hyalostelia* of Hinde. Some of them shew crutch-shaped terminations at the distal ends. Such remains of the body of the sponge as have been found, appear to consist of small cruciform and simple spicules, not unlike the *debris* of a modern *Hyalonema.* This sponge was larger than the preceding. It may be provisionolly named *H. Metissica.*

3. A third shews what seem to be remains of a thin-walled hollow sponge, with vertical and tranverse spicules arranged somewhat in the manner of those of the genus *Cyathophycus* of Walcott.[1] Like that genus, it contains also small loose cruciform spicules. It seems to have been conical and pointed below, and without long roots. It may be named *C. Quebecensis*.

4. Small ovoid masses of stout biacerate spicules, diverging from the centre and sometimes in fan-shaped tufts, seem to indicate a species of the genus *Lasiocladia* of Hinde. The specimens shew indications of an external membrane, and they had somewhat strong root spicules, much larger than those of the body.

5. Oval masses of small simple spicules, imbedded in patches of pyrite and without any definite arrangement of root spicules, may either indicate the presence of a halichondroid sponge, or of patches of spicules imbedded in coprolitic matter. The former is, perhaps. more likely to be the correct explanation.

An interesting point in connection with these remains is the appearance of so many distinct types of silicious sponges in one locality and formation. This fact was not distinctly noticed till the specimens were carefully examined, and it invites to further search in the locality, in hope of discovering new forms or more perfect examples of those represented in the present collection only by fragments.

[1] See note appended.

In the shales containing the above species, the only other fossils observed were slender fucoids, a small Obolella and a minute Cystidean or Crinoid, as follows :—

Obolella Ida ? Billings.

I refer the specimens of Brachiopods found to this species, which belongs to the Lévis division of the Quebec Group. The valves are mostly pyritized, but sometimes flattened and then represented by a mere carbonaceous film. Mr. Whiteaves, to whom I have shewn these shells, agrees with me on their probable reference to one of Mr. Billings' smaller species from the Quebec Group.

Cystites ?

A small-jointed stem one centimetre in length, with an elongated, flattened, oval mass at one end, in which, however, no distinct plates can be discovered.

Buthotrephis pergracilis. S. N.

Stems very long and flexuous, about one millimetre in diameter, and obscurely striate longitudinally ; sending off at their extremities short alternate or opposite branches. Allied to *B. gracilis*, Hall, of the Siluro-Cambrian, but much more elongated and slender. These plants are replaced by pyrite.

Note on Cyathophycus reticulatus. Walcott.

In the collection of minerals of the late J. S. Miller, Esq., of Ottawa, purchased for the University. are a few fossils, some of them Canadian, others from the phosphate deposits of South Carolina. Among the former are a few specimens of Utica slate fossils, which, from their appearance I suppose, have been collected in the beds of that formation near Ottawa, though it is possible that some of them may have been obtained from the United States. They include a specimen of the above species, which Mr. Ami, who has collected extensively in these beds at Ottawa, informs me has not yet occurred to him. The specimen is a small slab of the ordinary Utica shale, having an impression of a

glabella of *Triarthrus* on the back, which proves its geological horizon. It has two specimens of *Cyathophycus* close together, nearly perfect at their bases and broken off at the height of about three inches. They are perfectly flattened and pyritized, which is also the condition of other fossils in these shales, with the exception of the graptolites, which seem to have resisted this kind of change.

The genus *Cyathophycus* was originally described by Walcott from specimens obtained at Trenton, Oneida Co., New York.[1] He regarded it as an alga, whence the termination

[1] Trans. Albany Instit., 1879.

"phycus," but subsequently, in the *American Journal of Science*, 1881, corrected this error, and referred it to the sponges. Hall (35th Regents' Report) properly places it with the reticulate sponges included in his family *Dictyospongidae*, but does not add much to Walcott's original description, to which the present specimens permit some additions to be made.

The specimens are perfectly flattened, but show distinct indications of the two sides of the originally conical form. The wall of the skeleton has evidently been thin and composed of slender bundles, each of a few long simple spicules, and increasing both by bifurcation and the introduction of new bundles, so as to preserve nearly the same distances in the wider parts of the cone. They are very regular in the lower part, where there are about nine principal, with some intermediate secondary bundles in a centimetre, but become more irregular toward the top. This may, however, be an effect of decay and crushing. At the base these bundles become thicker, and in a specimen from the original New York locality, kindly lent to me by Mr. Ami, I have observed that they become expanded and converted into somewhat short clavate root spicules. This is, however, not apparent in Mr. Miller's specimens, which may have been broken off at the surface of the mud.

The vertical bundles are crossed at right angles by horizontal spicules much less regularly arranged, but dividing the surface into rectangular meshes. These are slightly

oblique and rhomboidal in the specimens, but this is probably due to pressure. The horizontal spicules seem to be triacerate in form, and much shorter than those of the vertical system, though of very different lengths. They are sometimes in bundles and sometimes solitary.

In parts of the substance, apparently within the reticulate wall, may be seen a few cruciform spicules, and flocculent patches apparently of very small spicules, which seem to have been mostly internal and most abundant toward the base, but cannot be distinctly made out.

The whole of the spicules are completely pyritized, and appear under the microscope to be made up of rows of cubical crystals of pyrites. They were probably originally siliceous, but this need not excite surprise, as the silica of such spicules is in a condition which facilitates solution, and in some modern sponges the spicules are not purely silicious, but contain some animal matter. I have also noticed other cases in which silicious palæozoic sponges have experienced this change, while in many specimens the spicules have entirely disappeared.

This is the case with the Erian or Devonian sponges of the genus *Dictyophpton* and allied genera, which, owing to their apparently membranous character, I at one time believed to be fucoids, but abandoned this idea on seeing the specimen of *Uphantenia* (*Physospongia*, Hall) which Prof. Whitfield was kind enough to show me in the New York Museum in July, 1881. In a note communicated to Prof. Whitfield in August, 1881, I have made the following remarks on the pyritization of sponges:—

"The most puzzling fact in connection with the original silicious character of these sponges is their mineral condition, as being now wholly replaced by pyrite. Carbonaceous structures are often replaced in this way, and so are also calcareous shells, especially when they contain much corneous matter, but such changes are not usual with silicious organisms. If the spicules were originally silicious, either they must have had large internal cavities which have been filled with pyrite, or the original material must have been

wholly dissolved out and its place occupied with pyrite. It is to be observed, however, that in fossil sponges the silicious matter has not infrequently been dissolved out, and its space left vacant or filled with other matters. I have specimens of *Astylospongia* from the Niagara formation which have thus been replaced by matter of a ferruginous color; and in a bundle of fibers, probably of a sponge allied to *Hyalonema* from the Upper Llandeilo of Scotland (since named *Hyalostelia* by Hinde[1]), I find the substance of the spicules entirely gone and the spaces formerly occupied by them empty. It should be added that joints of Crinoid stems and fronds of *Fenestella* occurring in the same specimen with the *Uphantaenia* are apparently in their natural calcareous state."

The type of structure of *Cyathophycus* is essentially that of the Hexactinellid sponges of the sub-order *Dictyonina* of Zittel, and under this, as has already been suggested by Barrois, it belongs to the family of *Dictyospongidæ*, established by Hall for *Dictyophyton* and the allied sponges of the Erian rocks. This type, already known as far back as the Utica slate, is now carried a stage farther by our discoveries at Métis.

While the above paper was in the press, Dr. Selwyn was so kind as to send to me for inspection, through Mr. Ami, of the Geological Survey, some slabs of gray and dark coloured shale from the Quebec group rocks of the Chaudière River, in which spicules of sponges had been detected some years ago, by Mr. T. C. Weston and Mr. Willmot of the Survey, but which have not been published. The specimens show two forms of cruciform spicules, one with very slender rays and as much as a centimetre in measurement from point to point, the other stouter and measuring about five millimetres in extent, and therefore more nearly resembling those of *Protospongia tetranema.* There are also long

[1] I have similarly explained *Pyritonema* of McCoy and *Eophyton explanatum* of Hicks, as has Hinde also, in Geol. Maga., 1886.

slender root spicules scattered on one of the slabs. On another specimen are large and strong forking spicules, the principal ray being about 1.5 centimetre in length, with a bulb or expansion at base, giving off two or more shorter and stout rays. They are quite different from any of the forms found at Metis.

These specimens are from beds referred to the Levis or Sillery formation, and are therefore approximately of the same age with those at Metis. They indicate the wide distribution of Hexactinellid silicious sponges in rocks of this period, and hold out the prospect of the discovery of additional species.

Mr. Ami also showed me a new sponge recently discovered by him in the Utica Shale at Ottawa. It consists of radiating groups of long slender simple spicules in a pyritized state. He hopes to make further collections from the same bed before describing these interesting forms, which resemble the spicules of the Pleistocene *Tethea Logani*, so common in the Leda clay of the St. Lawrence, but which may possibly be root spicules of a Hexactinallid sponge, as there are obscure cruciform spicules on the same slab.

Notes on Sponges from the Quebec Group at Mètis, and from the Utica Shale.

By George Jennings Hinde, Ph.D.[1]

Through the kindness of Sir J. W. Dawson, F.R.S., I have had the opportunity of studying a series of specimens of the fossil sponges lately discovered in the Quebec group at Little Métis by Dr. Harrington, and also of an example of *Cyathophycus reticulatus*, Walcott, from the Utica shale formation. The Metis specimens are specially interest-

[1] These Notes, kindly communicated by Dr. Hinde, arrived after the previous paper was in type; and are added without change. —J.W.D.

ing since they throw much fresh light on the character of the earliest known forms of these organisms, and their discovery is the more opportune from the fact that our knowledge of the existing hexactinellid sponges—the group to which all, or nearly all, these fossils belong—has been vastly increased by the work of Prof. F. E. Schulze, of Berlin, on the hexactinelled sponges dredged up by the Challenger expedition, and thus we are now better enabled than hitherto to compare the fossil and the recent forms.

Sir J. W. Dawson has already given a preliminary account of the character and stratigraphical relations of the rock in which the sponges occur, as well as some details of the fossils themselves, and at his invitation I now add some further comments thereto.

In the present specimens, the amorphous or soluble silica of which their spicular skeletons were originally composed, has entirely disappeared, and the spicules now consist of iron pyrites. This replacement by pyrites is of common occurrence, more particularly in a matrix of black shales; for example, the earliest known sponge, *Protospongia fenestrata*, Salter, from the Cambrian rocks of South Wales, is in the same mineral condition, and in a nearly similar matrix, as the specimens from the Quebec group and the Utica shale. When thus replaced, the general outline of the larger spicules is fairly distinct, but where the spicules are minute, and in close proximity to each other, their individual outlines are blurred by the tendency of the crystals of the replacing pyrites to amalgamate together so as to form a coutinuous film of the mineral in which the finer spicular structures are quite indistinguishable. This coalescence of the pyrites likewise makes it very difficult to determine whether the spicular elements of the sponge were organically soldered together into a silicious mesh, or whether they were merely held in their natural positions by the soft animal structures, and owe their present union to subsequent fossilization.

Next to the chemical changes, we have to take into

account those produced on the original structures of these sponges by what may be termed the mechanical influences of fossilization. There can be no doubt that they were hollow sacci-form or vasi-form structures with very delicate walls of spicular tissue, supporting the soft animal membranes. They existed at the surface of the soft ooze of the sea-bottom, probably their basal portions were embedded in it, and they were furnished with elongated spicules whose extension into the mud served to anchor them in one spot. After the death of the animal, and the decay of the soft tissues, the delicate skeletal framework would be gradually buried in the accumulating sediments, until by their weight it became completoly flattened. Under favorable circumstances, the outline of the sponge and the natural arrangement of the spicular skeleton would be preserved, and this is foıtunately the case with the specimens of *Cyathophycus* from the Utica shale, and to a partial extent with one of the specimens of *Protospongia tetranema.* More frequently, however, probably owing to currents and other causes acting at the surface ef the ooze, the skeletal framework is partially or wholly broken up, so that only small patches of the connected skeleton, or merely the dislocated and detached spicules irregularly scattered over the rock surface remain for determination, and this is the present condition of the majority of the specimens from the Quebec gronp. For some reason, probably connected with the arenaceous character of the rock in which they occur, the nearly allied sponges belonging to the Devonian genus, *Dictyophyton,* Hall, usually retain their outer forms complete—that is, without being compressed—but most of these sponges exhibit only internal casts of their spicular skeleton, so that at present we know very little of their original structures.

As already mentioned, nearly all these Quebec sponges belong to the sub-order of the Hexactinellidæ, in which the fundamental type or elementary spicule of the skeleton consists of six equal rays, radiating from a common centre at right angles to each other, forming three equal axes. But this typical form is subject to great modifications

through the unequal development or even suppression of one or more of the individual rays, so that spicules with five, four, three, or merely two rays only, are frequently present, and in the same species of sponge several modified forms of spicules may be found. Now, in the compressed condition in which the Quebec sponges occur, we can, as a rule, only perceive those rays of the spicules which lie in the exposed plane of the rock, these are generally the four transverse rays of the normal spicule, but the two rays forming the axis at right angles to the transverse rays, are not likely to be distinguished, for one would be concealed in the matrix immediately beneath the transverse rays, whilst the other, projecting above the exposed surface, would inevitably be broken away. Consequently it is very difficult to determine positively whether the forms with four transverse rays exposed on the plane of the sponge-wall, represent the entire spicule,—in which case it would be termed cruciform,—or whether one or both of the other rays of the normal spicules were originally present. Judging by the analogy of allied recent forms, it is probable that in most cases these spicules were furnished with a fifth ray at right angles to the other four. In the examples of *Cyathophycus* from the Utica shale, are distinct traces of a fifth ray in some of the larger spicules, and it can also be seen in a detached spicule on a slab from the Quebec group.

In both recent and fossil hexactinellids, many of the elongated filiform anchoring spicules terminate distinctly in four short recurved rays, and are thus five-rayed spicules in which one ray is greatly developed; but in other instances they have simple blunt or pointed ends, and may thus represent only one ray or one axis of the normal spicule. With one doubtful exception, all the anchoring spicules present in the Quebec sponges are merely pointed at their distal ends.

In recent hexactinellid sponges, in addition to the spicules forming the regular framework of the skeleton, there are much smaller spicules of varied forms, imbedded in the soft tissues. These, generally known as flesh-spicules, are

very seldom met with in the fossil condition, but it is not improbable that the delicate film of pyrites, seen in places on the surface of the Quebec sponges, may arise from the replacement of the flesh-spicules by this mineral.

Sir J. W. Dawson has already classified and given provisional names to the Quebec sponges, and it will therefore be more convenient for me to refer to their generic and specific details under these names.

Genus, PROTOSPONGIA, Salter.

Protospongia tetranema, Dawson.

In the one specimen in which the outline of the sponge has been preserved, the body appears to have been elongated oval, measuring about 45 mm. in length by 30 mm. in width. Very probably there was an aperture at the summit, though it cannot now be distinguished. The wall of the sponge appears to have consisted—as in the other species of this genus—of a single layer of cruciform (?) spicules of various dimensions, disposed so as to form a framework with quadrate or oblong interspaces; the rays of the larger spicules constituting the boundaries of the larger squares, and within these, secondary and smaller squares are marked out by smaller spicules. Judging by the length of the rays of the larger spicules, the larger squares would be about 6 mm. in diameter, whilst the smallest do not exceed 1 mm. The rays of the individual spicules slightly overlap, and it is probable that they may have been lightly cemented by silica at the points of contact. The rays of the larger spicules are conical, gradually tapering from the central node to the blunted extremity; whilst the rays of the smaller spicules appear to be nearly cylindrical.

From the base of the sponge, four slender elongated filiform spicules project. They are approximately cylindrical, pointed at both ends, from .1 to .25 mm. in thickness, and from 50 to 70 mm. in length. Their proximal ends are inserted apparently in the basal wall only of the sponge, and they project in the same direction, though not in lateral apposition with each other. In some specimens their distal ends converge and appear as if united terminally, but this may be merely due to chance overlapping.

This species appears to have been the prevailing form at Métis. Four specimens have been sent to me; in two of these the spicular frame-work of the body of the sponge retains in places its natural arrangement; in the other two the framework has been almost entirely broken up, and its constituent spicules irregularly mingled and compressed together. But in every specimen there are four anchoring spicules occupying the same relative position to the framework or body-wall of the sponge, thus clearly showing that they are essential to the species. In the spicules of the body-wall only four transverse rays can be distinguished, but it is quite possible, as already mentioned, that a fifth ray may have been present. On one of the rock-slabs there is a detached spicule in which the fragmentary stump of a fifth ray can be clearly seen projecting from the central node of the transverse rays. The rays in this spicule are unusually long, one can be traced for 30 mm.

There can be no hesitation in placing this form in the genus *Protospongia*, since the same arrangement of the spicular mesh-work is present in it as in the type of this genus. In no other examples of the genus, however, has the presence of anchoring spicules been recognized, owing, no doubt, to their imperfect state of preservation, and this feature may now be reckoned as one of the generic characters.

There are also differences of opinion as to the character of the spicular mesh-work and the systematic position of *Protospongia*, and fresh light on the points contested is afforded by these Quebec specimens. It has been doubted whether the body-wall of the sponge merely consisted of a single layer of spicules, or whether this layer corresponded to the dermal layer in other sponges of this group, and, as in these, was supplemented by an inner spicular skeleton. The evidence of the Quebec specimens favors the view that the body-wall of the sponge consisted only of a single layer of spicules. Various opinions have likewise been held as to whether the body-spicules were free, and merely held in their natural positions by the soft animal tissues, or

whether they were cemented together by silica at the points where their rays are in contact. Professor Sollas, in an able paper on the structure and affinities of the genus (Quart. Journ. Geol. Soc., Vol. 30, p. 366), asserts "that they are separate, and not united either by envelopment in a common coating or by ankylosis," whereas it has seemed to me that a certain degree of organic union must have existed to have allowed even the partial preservation of the mesh-work of the body-wall in the fossil state, and I have regarded the delicate film of pyrites which extends over the mesh-work in many specimens, as indicating a connected spicular membrane which served to hold the larger spicules in position. From the study of the Quebec specimens I still think a certain degree of organic attachment existed where the spicular rays were in contact, but I am quite prepared to admit that it was not of the same complete character as in typical Dictyonine hexactinellids. Prof. F. E. Schulze has clearly shown that a certain degree of irregular coalescence takes place in the body-spicules of undoubted Lyssakine sponges, and now that we know that *Protospongia* was furnished, like most of the sponges of this group, with anchoring spicules, there is good reason to regard this and the allied palæozoic genera as belonging rather to the Lissakine than to Dictyonine hexactinellids. This is the position assigned to them by Carter and Sollas.

Genus CYATHOPHYCUS, Walcott.

The two specimens of *Cyathophycus reticulatus*, Walcott, —the type species from the Utica shale*—exhibit the structural features so very clearly, that it seems desirable to refer to the generic characters, as shown in these specimens, before referring to the Métis specimens which have been placed in this genus.

The specimens are, as already described by Sir J. W. Dawson, compressed side by side on the surface of the same

*These specimens are from the collection of the late Mr. J. S. Miller, of Ottawa, and their locality is uncertain; but the formation is determined by a Trilobite on the same slab They perfectly resemble specimens from the original locality of Walcott in New York. J.W.D.

slab of shale; their spicules have been replaced by pyrites precisely the same as in the Métis specimens. The sponges were evidently vasiform, gradually increasing in width from the base upward, their summits have not been preserved, but with a length of 65 mm. they are 40 and 30 mm. in width, respectively. Owing to compression, the opposite walls are now nearly in contact, being only separated by a mere film of the shaly matrix, hardly half a millimetre in thickness. The shale has split in such a manner as to expose in some places the outer surface of the wall, and in others, the inner surface of the opposite wall.

The wall is very delicate, and consists of quadrate or oblong areas formed by slender longitudinal and transverse strands or fibers, of which the former are the more prominent. As in *Protospongia*, the quadrate areas are formed by the four transverse rays of cruciform, or five-rayed spicules, but these are disposed so that their rays overlap each other, and thus form fascicles of closely opposed parallel rays. The spicules in the transverse strands of the wall are less thickly grouped together, and even in some of the larger squares they may be arranged singly, whilst the smaller squares are generally bounded by single spicules only. The longitudinal strands principally consist of cruciform (?) spicules, but it is possible that elongated filiform spicules may likewise be present. There are plain indlcations of a fifth or distal ray in many of the principal spicules of the wall, shown by a very minute knob or blunted process projecting from the central node of the transverse rays, which may represent a partially developed ray, or the broken stump of a complete one. In some places, also, there is a continuous film of pyrites, probably indicating a membrane of very minute spicules or an agglomeration of flesh-spicules, now replaced by this mineral.

The basal portion of these specimens is incomplete, but there are indications of an extension of the longitudinal strands of the wall downward into the a tuft of anchoring spicules.

This genus is mainly distinguished from *protospongia* by the fascicular arrangement of the spicular rays in the prin-

cipal longitudinal and transverse fibres. The regular quadrate areas of the body-wall also mark it off from *Plectoderma* and *Phormosella*, Hinde. (See Brit. Foss. Sponges pt. i. pl. iii., figs. 1, 2 and pt. ii. p. 124-5, Pal. Soc., 1886-7.) How far it may resemble *Dictyophyton*,* Hall, and the other genera associated therewith by Prof. Hall [35th Report of the State Museum (1884) p. 465, pls. 18-21], it is impossible to state, for, so far as I am aware, the structural features of this genus have never been sufficiently described, and the characters assigned to the other genera are mainly those of external form, which, as regards this group of sponges, are hardly of generic importance.

The structures of *Cyathophycus*, as shown in these specimens, bears a great resemblance to that of the recent genus, *Holascus*, Schulze, (Challenger Reports, Vol. xxi., p. 85) based on sponges dredged from depths varying between 1375 and 2650 fathoms in the South Atlantic and in the Southern Ocean. There is a striking similarity in the structure of the sponge-wall in the fossil and in the original specimens described by Schulze, now in the British Museum of Natural History.

Cyathophycus Quebecensis, Dawson. (No. 3 of previous paper.)

One of the specimens thus named is the basal portion of an apparently elongated tubular sponge, the wall of which consists of cruciform spicules disposed in longitudinal and transverse fibres, as in the type of the genus. The specimen is too imperfect and the spicular mesh too broken up to permit of minute discription. On other rock-fragments are fibres or strands of straight elongated spicules, either parallel with each other or irregularly scattered over the

* If the spicular structure of *Dictyophyton* should prove similar to that of *Cyathophycus*, this latter named will have to be suppressed in favor of the former, which has the priority. Both these names, applied under the supposition that the organisms were plants, are alike unsuitable, and it might be advisable, as suggested by Prof. Whitfield, to reinstate Conrad's original name, *Hydnoceras*. [In the only species of the Dictyospongidæ in which I have seen structure, that named by Whitfield *Uphantenia Dawsoni* (Am. J.

surface and intermingled with detached cruciform spicules. These various forms may well have been the anchoring and body-spicules of examples of the same species, now disintegrated and compressed together.

Hyalostelia Metissica, Dawson. (No. 2 of previous paper.) This species is based on detached cruciform and anchoring spicules, the latter somewhat more robust than those placed as *C. Quebecensis.* In the present fragmentary condition of these forms it is impossible to give a satisfactory description, and the species must be regarded as provisional until better specimens are discovered.

Sponges of uncertain character. (Nos. 4 and 5 of previous paper.

On some of the slabs from Métis are small oval compressed patches, apparently consisting of small fusiform acerate spicules, sometimes parallel, at other times crossing each other irregularly. They do not stand out definitely as in the case of the hexactinellid sponge spicules, but appear to be embedded in some membrane. In two instances, anchoring spicules, like those of *Protospongia*, project from the base of the mass. I do not know of any monactinellid sponge furnished, as these appear to have been, with long anchoring spicules. Sir J. W. Dawson has suggested a resemblance to *Lasiocladia*, but they do not belong to this genus.

In another specimen an elongated space about 50 mm. in length by 16 in width, with well-defined margins, is covered with a thin film of pyrites, which may have resulted from the replacement of a mass of minute spicules, of which traces remain in some places, but no structure whatever can be recognized in it now. Sir J. W. Dawson has provisionally named the fossil *Halichondrites.*

Science, Aug., 1881, and Bulletin Am. Num. Nat. Hist., Dec., 1881), the spicules are apparently filiform and arranged in broad longitudinal and tranverse bund?es crossing each other, and with small, loose flesh-spicules in the meshes. They are therefore different from those of *Cyathophycns*, or, as it should now be called, *Cyathospongia.* *Hydnoceras* is liable to the objection that it was intended to indicate affinity to cephalopod shells. J. W. D.]

Examination of Some Manitoba Waters.

A. McGill, B. A., B. Sc.

The following results of the examination of the solids contained in certain waters from the Province of Manitoba, possess interest as illustrating to a certain extent the character of the water supplies in the region from which they were taken; a region whose mineral peculiarities have, as yet, come but little under the notice of the chemist. The object for which the assays were made, required only the estimation of the substances given in the table. I am indebted to the courtesy of W. R. Baker, Esq., Superintendent of the Manitoba and North Western Railway, for information regarding the sources of the water:

No. 1. From the *White Mud River*, at Westbourne.

No. 2. From the *White Mud River*, at Gladstone.

No. 3. From a well 30 feet deep, through sand and clay, at Portage la Prairie.

No. 4. From a well 30 feet deep, through sand and clay, at Neepawa.

No. 5. From a well at Minnedosa. The well is 20 feet in depth, through clay, hard pan, shale and gravel; and is situated a few hundred feet from the Little Saskatchewan River.

No. 6. From a well at Strathclair. The well is 34 feet deep, through blue and yellow clay, with boulders, sand and gravel.

No. 7. From a well at Rapid City. The well is 12 feet deep, through hard pan, shale and gravel.

No. 8. From a well at Kelloe. Total depth of well, 91 feet. It was sunk through hard boulder clay to a 12-inch vein of clay, under which water was found, which rose to a height of 40 feet in the well.

No. 9. From a well at Basswood. The well is 20 feet deep, through a quicksand.

No. 10. From a well 195 feet deep, at Birtle.

No. 11. From a well at the 174th mile of the Man. and N. W. R. R. The well is 162 feet deep.

In the table appended, all the results of analysis are expressed in parts per 100,000.

Sodium was estimated only in No. 8—and iron only in No. 1.

PARTS PER 100,000.

No.	1	2	3	4	5	6	7	8	9	10	11
Total suspended matter, dry at 100° C.......	Trace	Trace	Trace	Trace	Trace	Trace	2.0	2.5	1.6	17.5	11.7
Total dissolved matter, dry at 100° C.........	99.8	89.0	56.9	......	50.5	114.5	......	294.0	57.1	132.4	310.6
Same on ignition.........................	97.0	82.0	53.0	37.5	47.3	106.5	47.2	288.0	35.8	124.0	259 2
Silica, (SiO_2)	6.6	5.0	4.5	5.8	6.6	6.9	5.4	4.5	10.4	2.4	38.0
Chlorine (in chlorides).....................	5.98	2.16	0.77	0.63	0.84	0.77	1.11	20.88	0.696	4.176	5.29
Sulphuric Acid (stated as SO_3).............	7.69	10.57	7.037	0.996	9.714	36.637	9.339	112.67	0.277	47.775	127.31
Lime, (CaO)...............................	26.544	23.408	14.224	13.216	12.432	30.352	14.220	20.050	12.990	23.240	38.08
Magnesia, (MgO).........................	10.379	8.793	7.100	4.577	6.414	11.100	5.766	9.802	1.874	8.793	10.886
Sodium, (as NaCl).........................	......	......	......	......	......	......	......	177.0	......	......	......
Iron, (Fe).................................	0.36	......	......	......	......	......	......	......	......	......	......

On the Classification of the Cambrian Rocks in Acadia.

By G. F. Matthew, M.A., F.R.S.C.

[In continuation of a paper in this journal on a Basal Series of Cambrian Rocks in Acadia, Vol. III., No. 1, 1888.]

Our acquaintance with the Cambrian rocks of Eastern North America has now reached that point where it may be profitable to suggest the outlines of a general classification of these deposits, in accordance with the scheme laid down by the International Congress of Geologists.

By the term Cambrian, we understand the strata containing the Primordeal Fauna of Barrande, both those which contain it exclusively, and those which hold its later, modified representatives, mingled with the types of the Second Fauna; and also the antecedent forms, which lead up to the typical primordeal genera. The base of the system is defined in the preceding paper, and the summit is best marked by the appearance of the early typical graptolites of the genera *Tetragraptus*, *Didymograptus*, *Phyllograptus*, &c. These, with the associated trilobites of the Second Fauna, form the natural base of the Ordovician System.

Prof. Jules Marcou expresses a similar view in his limitation of the formations (terreins) which are included in the system called by him Taconic, but which is equivalent to the Cambrian, as defined above. His three divisions of the system are the Infra-primordeal, the Primordeal, and the Supra-primordeal. But, if Mr. Walcott is right in counting the Georgian Series as Middle Cambrian, the term Supra-primordeal hardly expresses the immense development in America of the Potsdam, in which many genera are analagous to those of the Second Fauna. Similar genera are found in the Regio Ceratopygarum of Angelin in Sweden, and in the "Fauna of Hof" in Bavaria, which Barrande did not exclude from the Primordeal Fauna.

At the base of the Cambrian System in Europe and other regions are comparatively barren measures, which, as their faunas are made known, will, no doubt, be found to Primor-

deal Fauna by biological links. Such is the Regio Fucoidarum of Angelin in Sweden, and the Caerfai Group in Wales. The process of unfolding the faunas of these initial terreins and stages of the Cambrian is now in progress, and has already given some remarkable results, both in Europe and America.

Applying these data to the classification of the Cambrian System in Acadia and Newfoundland, we find indications of the following series :—

Series A.—The Basal Series, or Eteminian.[1]
" B.—The St. John Group, or Acadian.
" C.—The Lower Potsdam, or Georgian.
" D.—The Potsdam Sandstone and Limestone.

Series A.

The terreins which in Newfoundland and Europe are supposed to be of equal age with this series, have been described in the previous paper.

There are, however, in America, further west, formations (terreins) that have been described by geologists as pre-Cambrian, some of which may be of equal age with this series. But as the Series B. has not been recognized in the central and western parts of North America, and these terreins have not yielded distinctive fossils, the means of determining their relation to the Eteminian Series are wanting.

Such formations are the Kewenawan and Animiki of Lake Superior, and the Chuar Group and underlying strata west of the Rocky Mountains. Messrs. Hague and Walcott were at first disposed to class the Chuar Group as Cambrian, but the latter now thinks it is of greater antiquity.

In the Lake Superior region no fauna older than that of the St. Peter's Sandstone has been established; so there remains the whole range of the Cambrian, as well as possibili-

[1] Named from the Etchemins, the aborigines of New Brunswick and Maine.

ties of older formations, within which the terreins around Lake Superior may be classed. Until the controversies relative to the comparative age of those rock masses are settled by the discovery of characteristic faunas, we cannot tell how they compare with the older series, or the Cambrian System, in Eastern North America.

SERIES B.

In speaking of the sub-divisions of this series, the writer proposes to use hereafter the terms recommended for divisions of a rank inferior to "Series." The term "Stage" will therefore take the place of "Division," as heretofore used in describing the parts of this terrein.

Stage 1. This includes the ·lower part of the series, as high up as Paradoxides are found. The divisions of this stage are as follows:—

Band (Assise) *a*. Hard grey sandstone or quartzite. Fossils: none known.

Band (or Assise) *b*. Dark-grey sandstones and grey sandy shales. Fossils: *Ellipsocephalus*, *Agraulos*, *Hipponicharion*, *Beyrichona*, &c.

Band (or Assise) *c*. Grey shales. Fossils: *Paradoxides*, *Conocoryphe*, *Liostracus*, *Microdiscus*, *Agnostus*, &c.

Band (or Assise) *d*. Dark-grey shales. Fossils: *Paradoxides*, *Ptychoparia*, *Solenopleura*, *Microdiscus*, *Agnostus*, &c., of different species from those in Assise *c*.

Stage 2. This consists of grey flags and sandy shales. The sub-divisions have not been worked out, but the stage corresponds to the lower half of the Olenus Zone in Europe. No species of the genus Olenus have been found in it.

Stage 3. Dark-grey and black shales. Fossils: *Ctenopyge*, *Kutorgina*, *Orthis*, &c. This corresponds to the upper half of the Olenus Zone of Europe. The shales in Cape Breton, which contain *Peltura* and *Sphærophthalmus* belong here. There are in the St. Joh

Basin grey flags, which overlie the Çtenopyge beds, but no higher stage than the Olenus Zone has been established by fossils.

Series C.

This, the "Lower Potsdam" of Billings, or "Georgian" of Mr. Walcott, has not been recognized on the main land of Acadia, but is found in the island of Cape Breton, where the fossils are *Bathyurus* (sub-gen ?), *Orthisina*, *Orthis*, *Hyolithes princeps.*

We place this series *provisionally* above the Series B. for reasons that will appear in the sequel, but a few considerations militating against this view may be mentioned.

Mr. A. Murray, late provincial geologist of Newfoundland, in his reports and sections of the Cambrian formation in the peninsula of Avalon, in that island,[1] places the limestone beds of Topsail Head and Brigus, in Conception Bay, below the Paradoxides beds. But, perhaps, it would be more correct to say that this limestone, by his observations, appears to be included in the Paradoxides Zone, as the horizon of Conocoryphe at Manuel Brook, not mentioned by him, is found below the limestone.[2] Mr. Walcott asserts that the fossils of this limestone belong to his Middle Cambrian or Georgian fauna, and explains the anomaly of their presence in the Paradoxides measures of Conception Bay, on the ground that they form an unconformable overlying series.[3]

Dr. W. C. Brögger, of Stockholm, in his review of the "Eureka Palæontology," urges several reasons for regarding the Georgian series as older than the Acadian.[4] Some of these reasons will be referred to hereafter, in connection with the genus Olenellus, but one may be mentioned here.

[1] Geol. Survey of Newfoundland, London, 1881, pp. 238 and 239.

[2] Mr. Murray includes in his section the conglomerate of Manual Brook, which is immediately below the Concorphe shale.

[3] U. States Geol. Survey, Bull 30, p. 49.

[4] Om alderen af Olenelluszonen i Nord Amerika, p. 195, &c.

In Europe it has been found that there is a great preponderance of species of Agnostus in the lower part of the Paradoxides Zone. There are in the—

Ceratopyge limestone and shale, 2 species.
Olenus Zone (4 in the lower part), 5 species.
Paradoxides Zone (25 in the lower part), 29 species.
Zone of Paradoxides (?) Kjerulfi, 0 species.

Dr. Brögger calls the last named the Olenellus Zone, on account of the genetic relations of Olenellus to *P.* (?) *Kjerulfi*, and compares the absence of the genus Agnostus at this horizon in Europe, with the scarcity of it in the true Olenellus Zone in America, and then shows that species of Agnostus are more numerous in the Acadian than the Georgian Series in America, as they are in the Paradoxides Zone, when compared with the Zone of Olenellus (?) Kjerulfi in Europe. But if the Olenellus Zone of America be compared with the Ceratopyge beds of Europe, it will be seen that that group also is characterized by a paucity of species of Agnostus.

One of the most characteristic genera of the Georgian Series is *Olenellus.* Of its close relationship to Paradoxides there can be no question, and yet it is associated with an assemblage of species differing widely from those of the Paradoxides Zone in Europe. There is the further remarkable feature that Olenellus is more closely related to the older species of Paradoxides, than to the later; indeed, so close is this relation to the earliest Paradoxidean form in Scandinavia, that this form, *P.* (gen. ?) *Kjerulfi*, has been called Olenellus. As long as the pygidium remained unknown, there was much to sustain this view of its generic relations; but now that this part of the organism (a very important part in the economy of the trilobites) has been recovered, and is found to conform to that of Paradoxides, and not of Olenellus, it is evident that the species cannot be referred to the latter genus.

On the other hand, the admirable study of this species carried out by Gerhard Holm[1] shows that it differs from

[1] "Om Olenellus Kjerulfi," in "Geol. Fören. i Stockholm," 1887.

Paradoxides in such important points, particularly in the absence of adorsal suture, as well as in having three prominent furrows on the glabella (in place of the two or four of Paradoxides), and especially in its peculiar hypostome, that it must be regarded as a genus intermediate between Paradoxides and Olenellus.[1]

Since Olenellus thus finds its nearest relative in the fauna of Series B., at the base of that series, are we, therefore, to regard the fauna of Series C, of which Olenellus is a part, as older than that of Series B.? If Mr. Murray's stratigraphical work in Newfoundland is correct, this would appear to be the case. In any event there is the possibility that Olenelloid forms in some part of the world, were contemporary with Paradoxidean forms in another part: but only the possibility, as the Paradoxidean stem may have thrown off genera resembling Olenellus in the earlier, as well as in the later stages of its existence.

Having considered some points which favour the view that the Georgian Fauna is of greater antiquity than the Acadian, we may now take notice of those which have a contrary tendency.

A prevalent and very striking genus of this series is *Dorypyge* of Dr. W. Dames.[2] Of this genus, one species (the type) is known in China and four in America.[3] In the latter region the species of this genus are found in the same layers with those which contain Olenellus,[4] and, therefore, are of equal antiquity. In China the latter genus has not been found with Dorypyge, which has with it only a Ptychoparian[5] form, telling only that the enclosing strata are Cambrian. Dr. Dames compares Dorypyge to Peltura and Parabolina, as the most

[1] It is to be hoped that his countrymen will see reason to connect Holm's name with this new genus.

[2] Included by Mr. Walcott in Olenoides, U. S. Geol. Surv. Bul. 30, p. 221.

[3] D. quadriceps, D. Wasachensis, D. Marcoui and D. Fordi.

[4] U. S. Geol. Survey Bull. 30, pp. 26 and 32.

[5] Liostracus megalurus, Dames.

nearly related genera ; to the former there is considerable resemblance, but the thorax and pygidium of the latter are of a different port. He also remarks of the rocks in China, in which this genus is found,[1] that there is, so far, no horizon in Europe to which, with confidence, they can be paralleled; but adds that there are some observations [which lead to the view] that the slates with Dorypyge belong to the horizon of the Scandinavian Ceratopyge limestone. Species of other genera occurring with the Chinese Dorypyge have been compared by Dr. Dames with those of the Potsdam sandstone in Wisconsin, especially with those of the central portion of that formation. These sandstones are regarded by Walcott as younger than the Georgian series; so in the associated genera there is nothing to lead to the supposition that Dorypyge marks an older horizon than the Ceratopyge limestone and shale. Dr. Brögger also admits that Dames places together the Chinese limestone with Dorypyge and the Ceratopyge limestone of Sweden.[2]

As for Olenoides (proper) of Meek, we see in it a much closer relation to Parabolina of the European Cambrian beds than can be observed in Dorypyge. To judge by the sections of the Cambrian rocks in Western North America, given by Mr. Walcott, the genus belongs to a somewhat higher horizon than Olenellus and Dorypyge, a conclusion which may also be gathered from the species of other genera associated with it. Olenoides may be considered as having its representatives in Europe in the upper part of the Olenus Zone.

Another consideration which militates against the greater antiquity of the Georgian Series is the presence in it of several genera of trilobites as *Protypus*, *Bathyuriscus* and *Asaphiscus*,[3] in which the size of the head-shield, thorax and pygidium are nearly equal. Such genera predominate in

[1] Cambrian trilobites of Liau-tung, China, p. 33. in Richthofen's China, vol. iv.

[2] On alderen, &c., p.

[3] Compare *Nileus* and *Niobe* of the Tremadoc and Ceratopyge beds, with these genera.

the Ordovician or Second Fauna, and in Europe they first appear about the horizon of the Ceratopyge shales.

Other trilobites help to establish this connection, as the Chinese Conocephalites,[2] and Dames himself compares the Chinese Agnostus with *A. cyclopyge* of the upper part of the Olenus Zone in Europe, and with species of Lower and Upper Potsdam age in America.

These observations on the trilobites serve to show that the fauna, of which they form a part, is younger than the Acadian series, or at least younger than Stages 1 and 2 of that series. If, on the other hand, we were to regard the Georgian Series as the older, we would be met by greater anomalies in the vertical distribution of the genera than if we adopt Dames' suggestion as to the age of the corresponding series in China, and place it with the Scandinavian Ceratopyge limestone.

Similar arguments as to the more recent age of the Georgian fauna might be drawn from the brachiopods; among which Orthisina may be referred to. This genus is unknown in the Acadian Series, and in Europe we do not know of it in the Cambrian at all; but it is a well-known genus of the Ordovician system. Hence the presence of three species of this genus in the Georgian fauna gives it, as a Cambrian fauna, a decidedly modern facies.

The palæontological relations of the Georgian fauna may be summed up in the table on the following page, from which it will appear that they are decidedly with the faunas of the upper rather than the lower part of the Cambrian System:—

[2] Compare *Conocephalites typus*, Dames, with *C. teucer*, Billings; also *Anomocare latilimbatum*, Dames, with *Ptychoparia Pichoensis*, Walcott; also, *A. planum*, Dames, with *Conocephalites Adamsi*, Billings.

Affinities of the Characteristic Genera of the Georgian Fauna.

Cambrian in Europe, principal part.		Stages of the Acadian Series.
4. Ceratopyge limestone and shale.	Orthisina affinities, with species above 4.	
	Bathyuriscus, Asaphiscus, Protypus } affinities with genera in 4 and above.	
3. Upper Olenus beds.	Bathynotus affinities with genera in 3 and above.	Stage 3.
	Dorypyge affinities with genera in 3 and 4.	
2. Lower Olenus beds.	Ptychoparia " " species in 3 and 4.	Stage 2.
	Agnostus " " " in 3.	
	Olenoides " " genera in 3.	
1. Paradoxides beds.	Microdiscus " " species in 1.	Stage 1.
	Olenellus " " genera in 1.	
	Mesonacis " " genera in 1.	

A further point for consideration, seeing that the Georgian Series, by its fauna, is for the most part younger than the Acadian, is as to whether it overlaps the latter; that is, whether the Georgian epoch was cotemporary with the closing part of the Acadian. The majority of the trilobites of the Georgian may be said to compare with those which in Europe, mark the upper part of the Olenus Zone and the Ceratopyge beds; but this is by resembling genera only, while we know Stage 3 of the Acadian Series to be equivalent to the upper part of the Olenus Zone by identical genera, and even by identical species. The upper part of the Acadian would, therefore, be near the Georgian in time; but whether it is cotemporary with the latter or not, can only be established by an examination of the region where they come together, namely, in Cape Breton and Newfoundland. In the former island they are separated only by a low, narrow range of pre-Cambrian hills, and in Newfoundland, according to Mr. Walcott, they

are in actual contact; yet we do not know that in either of these islands there it any mingling of the two faunas. In the St. Lawrence Valley and Gulf, the Georgian Series is present at several localities, but no trace of the Acadian has been found. These conditions seem to indicate that the two series are entirely independent of each other, in which case the Georgian would be the more recent.

But if there is no overlap, as would appear from these conditions, then the Georgian can be of no greater antiquity than the Ceratopyge beds, and the 4,800 feet of Middle and Upper Cambrian in the Eureka district west of the Rocky Mountains, would be represented by the 1,000 of the Tremadoc Group in Wales, or the very much thinner Ceratopyge beds of Sweden.

Series D.

Of the relation of the Potsdam Series to the Georgian there is less doubt than hangs around the connection of the latter with the Acadian Series. Mr. Walcott's fortunate discovery of the highest bed of this series in the Saratoga limestone, has enabled him to show its equivalency to the highest Cambrian sandstone in Wisconsin. This group, characterized by the genus Dikellocephalus of Owen, appears to be equivalent to the Ceratopyge limestone, or the Tremadoc Group, and would represent the upper part of the Tremadoc, as the Georgian Series probably does the lower.

This, the upper, or true Potsdam, appears to form in Eastern North America a fourth series of the Cambrian system, since its distribution is not coincident with that of the Series C.,, but it is apparently wanting in the region to which this article relates. The Potsdam series is present in the upper part of the St. Lawrence Valley, and in the middle and Western States, but absent, as far as known, from the eastern border of the continent.

In Eastern North America, then, the Cambrian System is represented by the following series:—

	New England.	N'w Brunswick	Nova Scotia.	Newfoundland.
Series D., (Potsdam)	present, at the western border.	not known.	not known.	not known.
Series C., (Georgian	present, at the western border.	not known.	present.	present.
Series B., (Acadian)	present, on the Atlantic coast.	present.	present.	present.
Series A., (Eteminian)	not known.	present.	not known.	present.

THE CLIMATE OF THE CANADIAN WEST.[1]

By ERNEST INGERSOLL.

It may seem presumptuous in me, the citizen of an outside power, however friendly, to come before an audience of Canadians as a lecturer upon their own country. But, in extenuation, I may plead that it has been my fortune to travel a great deal in all parts of Western America from Mexico to British Columbia; and, consequently, that I am not speaking from hearsay alone, but in the light of personal experience.

The climate, or rather climates, for there are several distinct climatic areas, of the vast western half of Canada, is, however, a matter of fact and science rather than of experience, and an intelligent man, though he had never been west of Lake Superior, nor heard a single word about its actual weather, could predict with much accuracy what kind of climate would be met by explorers in each of its various divisions, simply from knowing the physical situation of each.

For climate is very largely—almost wholly—a function, as mathematicians say, of, first, the latitude, and, second, the physical geography of the region under consideration.

[1] Abstract of a lecture in the Somerville Course, delivered in Montreal, March 15th, 1888.

By physical geography, I mean, here, the way in which the seas, mountains and plains of a sufficiently large district are disposed towards each other; and it is due to the close relation existing between these diversities of surface and climate, that the latter is not a whimsical thing, but one of the steadiest and most characteristic features of any region—even though the *weather* there may, at certain seasons, be most capricious.

The Canadian West I take to mean, for the purposes of this lecture, all of north-eastern America, from the limits of the forests around Hudson's Bay and Lake Superior, westward to the Pacific Ocean.

A glance at the map is the first thing in order.

We find that north of the International boundary line—or, better, let us say north of the watershed between Canadian rivers and those tributary to the Mississippi and the Missouri—there is an immense area of treeless plains nearly a thousand miles wide east and west, and stretching north-west, in triangular form, to the border of Alaska. This may be said to be *one* climatic area, which we may call that of the Plains.

West of the Plains stand the serried ranks of the grand old Rockies, forming a belt of snow-bearing mountains averaging 200 miles in breadth, and rising everywhere into tne zone of perpetual snow and ice. This belt has a climate of its own, which we may term that of the Rocky Mountains. Beyond this lies the interior basin of British Columbia, about as large as Manitoba, forming a third climatic area, which may be named the *Kamloops* Climate, for want of a better term. A fourth climate, that of the rainy Coast Range, is attached to the narrow but lofty rank of mountains improperly called the Cascades, which extend parallel with the Pacific coast in southern British Columbia, and form the coast itself in the northern part of that Province. Last of all, there is the strip of lowland and the tongue-like valleys along the coast itself, together with the islands bordering it, which constitute a fifth climatic area. Each of these divisions is, in fact, a long strip of country,

north and south, conforming to the lines of coast and mountain ranges, by which their peculiarities in each case are governed.

We have, then, five separate and natural divisions of the West, each characterized by a climate of its own, depending upon its natural condition, as follows:—

1st—The Plains.

2nd—The Rocky Mountains.

3rd—The Interior of British Columbia.

4th—The Coast Mountains.

5th—The Pacific Littoral.

Let us take these up in reverse order, and so prepare ourselves for a study of the Plains, in which most persons are mainly interested.

It is almost needful, however, to consider the whole West as one, at first, in order to get at the philosophy of the subject in each separate ease.

Remembering the northerly position of Canada, which gives it the general climatic features belonging to the Temperate Zone, we may say that every local peculiarity of climate in the West—at least beyond the central part of the Plains—is due to the arrangement of the currents of the Pacific Ocean, and its winds, on one hand, and to the position of the mountains in reference to them on the other. The reaction of ocean and mountains—of their influences, that is—upon each other, is really what makes the climate; and as the ocean currents and world-winds flow uniformly and unceasingly, while the mountains stand as the very type of permanence,—this reaction is necessarily constant, followed, of course, by uniformity in the visible effects.

With the course of the Gulf Stream all are familiar, and rightly attribute to its indirect influence the warm and moist climate of Great Britain and France, though those countries are as near to the arctic pole as the frigid cliffs of Labrador, where perennial winter holds sway.

Now, in the Pacific the case is the same. A great warm current out of the tropical seas courses up the eastern coast of Asia until it is fended away by the headlands of Siberia

and the Alaskan islands, and then turns to sweep southward along the coast of British America. The prevailing winds there, as everywhere else in the North Temperate Zone, are from the West; and these, after passing across thousands of miles of unobstructed and well-warmed ocean, come to us loaded with moisture. Warm air, you must remember, because expanded by its warmth, will absorb more moisture than cold, so that these Pacific winds are saturated by the time they reach the shore.

Now the mountains begin to do their part.

One cannot appreciate how important is the influence of the mountains of the globe upon its climates, until he stops to think what a state of things would exist in their absence. Weather is simply the state of the atmosphere in respect to temperature, dryness or wetness and the like. What affects these conditions causes a change in the weather. Were the surface of the continents flat, temperature would decrease from the equator precisely in ratio with the latitude, subject only to the influence of winds from the ocean, which would blow with unfailing regularity and continuance, bearing a definite quantity of moisture and depositing it, probably unceasingly, in the same place, year after year. Heat and cold in climate would then be almost entirely a matter of summer or winter, or distance from the equator, and wet weather would belong wholly to certain zones, migrating with the seasons, while all the rest of the world would be arid.

But the irregularities of the surface of the globe interfere with this, and make it a tolerable place to live. Without mountains (if we can conceive of such a state of things) the earth would scarcely be habitable—or at any rate comfortable. But the hills rise up toward the spaces of eternal frost which encircle the globe only a few thousand feet overhead, and act as condensers. The damp ocean air coming near them is cooled down to its dew point—that is, to a point where the invisible vapor of water it carries is changed into perceptible drops, clouds are formed and perhaps rain falls.

The higher the mountains, of course, the greater must be the condensation, because lofty summits are necessarily colder than those of less altitude.

With these general facts in view, let us now enquire as to the particular climates of British Columbia, which is to an extraordinary degree, a region of mountains and sea coast.

Vancouver Island and the Queen Charlotte archipelago have a climate upon which the inhabitants congratulate themselves. They have a mild and even winter, with rain, (the annual rainfall is estimated at 45 inches) and occasionally snow; an early spring; a dry, warm summer, and a clear, bright and enjoyable autumn. Sometimes the frost is sufficiently hard to permit of skating, but this is exceptional. As a rule flowers bloom in the gardens of Victoria throughout the year. The climate is warmer than that of England, and the rainfall is periodic—not irregular. The summer is decidedly dry, so that dust is one of the greatest inconveniences in every settlement. But it is a curious fact that July, the dryest month on the coast, is the time of greatest wet in the interior. Fruits of all kinds indigenous of the temperate climates ripen in the open air, air, and amongst them some that are in England brought to perfection only under glass. Some of my hearers may remember an exhibition of apples, embracing some thirty varieties, all of extraordinary perfection, which grew near the mouth of the Fraser and were exhibited here in the early part of the winter. I have never seen plums and cherries to approach in size or flavor those of that region; and fruit culture will surely be one of the leading industries in the future of that coast. Thunder storms seldom break over the island. They can be heard in the distance but are rarely experienced. It is this climate, combined with the situation of Victoria, that makes that city so pleasing a contrast to those who visit it from the hot valleys of California.

Yet in the Interior of Vancouver Island mountains that rise more than 6,000 feet above the sea level not only hold the snow the year round, but even bear glaciers of large

size; and the climate of the Queen Charlotte Islands is cooler and more rainy than that of Vancouver, whose northern end, in turn, is less pleasant than its southern part.

Between the western, or oceanic, border of Vancouver Island, and the mainland coast, there is considerable difference, in favor of increased dryness and greater thermometrical range. That is, it becomes colder in mid-winter, and hotter in mid-summer than on the outer coast of the island. But the extreme in neither season is a hardship, and, on the whole, New Westminster and the new city of Vancouver have an even more agreeable climate than Victoria. People wear the same clothes the year round, and an umbrella must be a pretty constant part of one's outfit, except during the long and beautiful autumn, which is like a far-extended Indian summer.

The explanation of this climate has already been hinted at. The water of the Pacific is warm—20 degrees warmer than that of the North Atlantic near Canadian shores.

The prevailing south-westerly winds, sweeping over its surface, are raised to the temperature of the water, and become saturated with moisture, abstracting from it, and rendering "latent," in conformity with well-known physical laws, a still greater quantity of heat. Wh n, on reaching the mountainous coast, this moisture is condensed and discharged, the latent heat becomes again apparent, and greatly raises the temperature of the atmosphere in which the reaction occurs. Hence the coast climate of the whole north-west coast of North America is warm. The mean annual temperature of Sitka is nearly the same as that of Montreal.

That the climate is wet as well as warm, is owing to the effect of the height of the coasts. The heaviest rainfall occurs in exact correspondence with the height to which the moist air is forced into the higher regions of the atmosphere, and cooled there by its expansion and loss of heat by radiation. In proportion to the elevation of the islands, and the degrees in which they shelter the mainland coast from the rain-bearing winds, the rain fall on the opposite coast

is more or less. The comparatively less rainfall of the coast of the south-western section of the mainland, (New Westminster district) than farther north, is owing to the abstraction of part of the moisture of the rain-bearing winds by their striking the mountains on Vancouver Island (where it is very wet), and to the lowness of the land about the mouth of the Fraser river.

This dampness produces that extraordinary growth of gigantic forests and vegetation characteristic of the Pacific slope; but this vegetation is distinctly northern in type, and the climate is far removed from a tropical one, where summer is eternal and proportionately enervating to man and beast. It is, on the contrary, though drier and steadier than England, in ordinary seasons not unlike the western counties, more particularly Devon and Cornwall.

Passing over the uninhabited ranges popularly known as the Cascades, whose summits reach eternal frost, and whose gorges are wet and densely wooded, we emerge on this side into a wholly different region. Instead of the lowlands of the Fraser delta, and the forests of almost tropical luxuriance that choke the narrow mountain-valleys, whose slopes are running with copious streams fed by an almost incessant rainfall, we have here, in the interior of British Columbia, wide areas of grassy plateus and rounded hilltops. The rainfall of this southern interior is, in fact, slight and intermittent, and is insufficient for agriculture, so that farming must rely upon irrigation. For grazing, however, this condition of things is most favorable, and stockraising is likely to be the principal industry as far north as the rough, wooded country, which begins some 50 miles north of the railway. Yet the sky is often heavily clouded; but these clouds sweep overhead from west to east without shedding a drop of rain, though it may fall for days at a time on the mountains each side. The explanation, undoubtedly is: that the hot air, ascending from the heated and treeless plateau continually buoys up the clouds, and at the same time keeps them warmed above the point of condensation. Once in a while there is an interruption of this equilibrium in the shape of what is

called a "cloud burst," when the rain will fall in a deluge upon some limited space. It may truly be said of a region like this, that it never rains but it pours. This steady dryness of climate, coupled with its small altitude, makes the Kamloops and Okinagan districts a most excellent retreat for persons with pulmonary maladies, and many men are living there in health, who, would not have survived within years of this time had they remained in eastern Canada. Here, where the thermometer rises occasionally to 110° in mid-summer, and the breeze is like the breath from the door of a furnace, the boastful natives have much to say of the refreshing effect of the cool nights. So they do on the coast, where the very air is sometimes greasy with warm steam and your strength dissolves as in a Turkish bath. But that claim is a matter of course! If there is one thing in this delusive world more certain than another, it is that every son of Adam will tell his friends (and most of all his enemies!) that where *he* lives the nights are cool and there are no mosquitoes.

But to resume: The winds that have swept ungenerously over the Kamloops downs are compelled to yield their burdens of moisture to the mountains on this side of the great Thompson River basin. Here the Gold Range, stretching north and south for 200 miles along the western bank of the Columbia, rears its ancient peaks into the sky and interrupts the westerly gales. Striking this cold barrier, the air is suddenly condensed and drops its rain. One would think, after seeing the downpour upon the Cascades that little would be left in the clouds for any region beyond; yet the Gold Range is as damp as the Cascade, and its fountains nourish the great group of the Shushwap and Okinagan lakes, and keep alive many rivers of the first class.

But the Gold Range is only the westernmost of three huge mountain-ranks, which together form the great *Cordillera* of Canada, a belt of snowy mountains 250 miles in width. It is fifty miles across the Gold Range from Great Shuswap Lake to the Columbia river: It is sixty miles across the Selkirks from the Columbia on the west to the same river on the east of the range; and it is 125 miles from that river

across the Rocky Mountains to the plains. None of these three divisions is formed by a single line of elevations, but each consists of lines and groups of mountains almost untraceable in their confusion. They stand athwart prevailing winds, and hundreds of their peaks rise far into the chill regions of upper air, where winter is perennial. The highest are nearest the eastern border, and by the time the winds from the Pacific Coast have struggled between the crags, and swept across the wide snow-fields and ice-beds of the Selkirks and the Rockies, they are almost as dry as the dust of a flour-mill. Hence, of course, the rain-fall and snow-fall are far greater in the Gold and Selkirk ranges, first encountered, than in the Rockies; and the western side of each range is far more wet than the eastern. The snow-fall in the Selkirks amounts to about 30ft. in depth, yet winter there is hardly three months long, and the weather, as a rule, is so mild that explorers and workmen find little inconvenience in tents and shanties, and are only comfortable at work by taking off all their coats and laboring in their shirtsleeves. In the Rockies, on the contrary, the snow-fall is comparatively light, and what falls wastes rapidly, so that the railway is never incommoded in this range. The cold, on the contrary, is often very severe, and the winter of longer duration than in the Selkirks. This contrast is easily explained: We have seen that the warm and damp currents of air from the Pacific Ocean are gradually deprived of their moisture by condensation against the cold peaks of the Gold and the Selkirk ranges of mountains, so that they reach the Rockies almost dry. The very fact of its contact with the ice and snow must cool the air somewhat, of course, but the philosophical explanation is behind this—the *warm* winds of the coast are *cool* winds in the Rockies, because they have become dry winds. In giving up their moisture by condensation they have lost heat; and in their further rarification, due to their lofty flight over the high peaks, they have parted with still more heat, in exact proportion to the height ot their ascent. Everyone who has climbed a mountain or gone up in a balloon, has noted how

the coolness of the air increases in pace with its rarification. Professor McCleod, in the second lecture of this course, made this plain by his diagrams, showing how an increase of altitude above the sea is equal to an increase of latitude away from the Equator, until, on the tops of very lofty mountains truly polar weather exists. The summits of the eastern Rockies are not much higher, however, than the crests of the Gold and Selkirk ranges; and they are colder than their more western compeers, not because they are higher, but because they are more inland, and hence receive air already dry, rarified and well cooled.

It is this characteristic of the atmosphere of the eastern side of the Rockies—in the neighborhood of Banff Springs, for instance—which gives it such a sanitary value, particularly in diseases of the lungs and throat.

Now let us make a hasty review: The winds of British Columbia are, broadly speaking, from the west. They are warm from the ocean, and loaded with moisture. Condensing into fog at the coast, they give a uniform, English-like, muggy climate along the Pacific coast. Further condensed, they are less foggy, but produce a more cloudy sky and heavier rainfall on the coast mountains. Raised to the elevation of the crest of the Cascades or Coast range, they take a flying leap across the interior basin, discharging little rain on the Thompson valley,—leaving it subject to extreme cold in winter, excessive heat in summer, and drought all the time. Condensed again by the Gold Range, the moist winds give those mountains rain and heat almost equal to that of the Coast Range. Condensed still further, by the Selkirks, there is a copious rainfall and snowfall upon these mountains, and a further giving up of warmth, which greatly tempers the climate; but by the time the Selkirks are past, the winds have lost nearly all their moisture and warmth, and have been rarified by being forced to an average height of seven or eight thousand feet. Hence, when they pass to the Rockies they are dry and cool in summer—dry and very cold in winter. What little humidity and warmth they may retain is almost lost on the western slope,

and at the summit of the Rockies the atmosphere is almost perfectly thin, dry and cold. The eastern slope of the Rockies is sparsely supplied with trees, and those of small size, while the rivers are scanty, except those fed by the glaciers and great snow banks conserved upon the cold central heights, and slowly doled out to keep the streams running. No great freshets occur, as happens upon the Pacific slope.

Yet the eastern foothills of the Rockies have a milder climate, and earlier spring and less snow than the western base of the range. Why? Owing to the Chinook winds. But what are the Chinook winds? Currents of warm air—broad sheets—cataracts—of warm air falling down in mid-winter from the top of the Rockies. But why, if the air on the crest, where the wide spaces of snow lie, is deadly cold, should the breezes decending from those snow-fields be comfortably warm in winter? Simply because they *do* descend.

Here is the reversal of the previous condition. The air ascending the western side and at the top of the Rockies is cold because it is losing its moisture and becoming rarified; the air descending the eastern slope becomes condensed, picks up moisture with every part of its descent, and correspondingly develops, or gives up, the latent heat which invariably accompanies condensation, The Chinook, then, is a warm dry wind, manufactured on the spot by the condensation of the mountain air as it sweeps down, increasing in density, absorbing moisture, and yielding up its latent heat. In summer the same breeze seems cool in comparison with the fierce radiation of the baked plains; but it is equally a Chinook.

This wind is marvelous in its effect. To it is due the pleasing dryness of even the deepest gorges and nooks in the rocks in summer, while in winter it clears the plains for hundreds of miles away from the mountains of nearly all the snow—always scanty in amount—with amazing celerity. A northern gale will blow for two or three days, forcing the mercury below zero, and bringing all the wide plains under

a foot or two of drifted snow. Cattle, horses and wild game can only huddle in sheltered hollows or hide among the groves along the river banks and hope for better times. All the pasture is covered with a blanket of snow, too deep to let an animal get a bite of grass. Then the wind lulls and a breeze from the west springs up. It is warm—almost balmy in contrast to the biting easterly or northerly snow-gales. Near the mountains only a few hours suffices to lick up all the snow, except from the gullies, into which it may have drifted to a great depth. Cattle and horses find the grass exposed, and resume their feeding. The cold has done them no harm, for there has been no wet snow or sleet. The genial influence of the balmy west wind is felt far down the Mackenzie, enabling the buffalo to wander almost as far as the arctic circle in that part of the country. Winter there, in fact, is neither so long nor so severe as on the lofty plateaus fifteen hundred miles southward, for the height above the sea is only a few hundred, instead of several thousand feet. McKenzie found spring along Peace River, in latitude 56°, so advanced by the 10th of May that the buffalo and their young were cropping the new grass on some of the most exposed uplands.

Eastward from the mountains the influence of the Chinook gradually fades out, and is superseded by the northerly and southerly currents of Manitoba, which flow up and down the great trough of Lake Winnipeg, the Red River valley, and the valley of the upper Mississippi.

In respect to the climate of Manitoba and the Saskatchewan prairies, there is one man to whom all of us are indebted for information drawn from an untiring and early experience, and sustained by a sound judgment. I refer to Prof. John Macoun, of the Geological Survey. His book "Manitoba and the Great Northwest," is a most admirable compendium of information in regard to all the natural aspects of that great region, and I have had it constantly before me in writing out these notes.

The Canadian plains, as has already been said, stretch from Red River westward to the Rocky Mountains, and

northward to the forests beyond the Saskatchewan — an area as spacious as Ontario and Quebec together. Over all this area a fair uniformity of climate prevails, characterized by a rigorous, but comparatively short winter, early spring, an intense and fairly rainy summer, and a prolonged dry autumn. The air is dry, healthy and invigorating, the warmth and rainfall favorable to agriculture, the winter weather and light snowfall well adapted to success in raising live-stock. Indian-corn and apples can be grown to the 50th parallel of latitude in Manitoba and still higher farther west; while wheat, barley and all the hardy vegetables attain full ripeness on the banks of the Peace River, in latitude 50°, —the parallel which touches the southern extremity of Greenland.

At Fort Dunvegan, on Peace River, thirteen degrees north of Toronto, or nearly as far as Cuba is south of it, the winters, as I have said, are milder than those of Manitoba or Ontario; and for the seven months, from April to October, constituting the period of cultivation, Dunvegan and Toronto do not vary more than about one-half a degree in average temperature; while, as compared with Halifax, the difference is in favor of Dunvegan. The frosts there do not linger in the spring as late as here in the neighborhood of Montreal, nor do they begin so early in the fall;—and everything which will grow here will ripen there, in many cases with greater luxuriance. Out of 212 species of plants seen along Peace River, near Dunvegan, 138 grow in the vicinity of Toronto, and the rest are such as belong to the Saskatchewan plains. The list includes a native cactus!

In view of these facts, it is evident that mere difference of latitude is of small account; and when we come to examine the isothermal lines marking similarity of mean summer temperature, we find that they curve far northward, the isotherm of an average summer temperature of 65°, which is that of this part of Quebec, curving through Georgian Bay, along the south shore of Lake Superior, and swinging northward through Manitoba and north of the Saskatchewan almost to Peace River. In other words, the

temperature in summer of the North Saskatchewan and Peace River valleys is substantially the same as that of Montreal and Quebec. Similarly, the isothermal lines that pass through the thickly settled districts near the southern boundary of the plains are those of northern Ohio and Illinois. In fact, it is a truth proved by long observation, that the summer climate, in relation to agriculture, is warmer all over the western plains than it is in central Ontario. Spring opens earlier, too. Plowing is very often begun, all the long way from Red River to the Rockies, by the last week in March; and in Manitoba, which is the coldest corner, spring is never postponed beyond April 5. In the fall, on the other hand, plowing may generally be continued until the first of December, and sometimes much later. The Lethbridge *News*, of February 16th, this year, (Lethbridge is near Fort McLeod, 100 miles south of Calgary), says: "Winter is generally believed to be practically at an end. The thermometer registered 57° at noon." Early in April, then, the sun dissipates the light snow, the dry air evaporates it, leaving the ground dry, and plowing and seeding go on simultaneously. In a few days the seed germinates, owing to the hot sunshine. The roots receive an abundance of moisture from the thawing soil, and penetrate to an astonishing depth into the loosened loam. By the time the rains and heat of June have come, abundance of roots have formed and the crop rushes to quick maturity. The enormous crops are owing just as much to the opening power of the frost as to the fertility of the soil; this is a peculiarly favorable effect of the swift change from sharp cold to intense heat which characterizes the climate of that region. The summer weather is often extremely hot—frequently reaching 100 degrees; but this is a scorching, not a sweltering heat. It is the direct burning of the sun's rays—not a heat resident in the air: hence you mark an instantaneous and grateful relief when you step into the shade, or catch the breeze. Sunstrokes and loss of vigor through heat, which so often accompany summer days here when the mercury may not go so very high, are almost un-

known effects in the West. I hesitate to mention the dear old claim of cool nights, dreading your smiles, yet it is a fact that as a rule they are too cool to sleep uncovered; and a *sultry* night is more rare, even, than a sultry day. This intensity of the heat makes up for the comparative shortness of the season of cultivation, urging grain to a far greater celerity of growth than proceeds in more southerly latitudes: nor should it be forgotten that the high latitude gives greater length of days—far more sunshine and growing time in each 24 hours—than can be had further south. On the Saskatchewan in midsummer the nights are only four or five hours long. It thus happens that vegetation has about as many working hours, so to speak—hours when sunlight is promoting growth—between seed time and harvest, as in the longer season but shorter days of Iowa.

This increased energy of growth has been remarkably manifested in some instances. The early spring wheat cultivated for forty years in the Selkirk settlement, before the birth of Manitoba, was originally an English winter wheat. More lately a winter wheat from Pennsylvania was transformed into a spring wheat in Manitoba after a single year's reproduction. The seed of a certain kind of Indian corn cultivated about Winnipeg was two weeks later in maturing when sown near St. Louis, whence it had originally been brought; but quickness in coming to maturity is in fact, characteristic of all the plants indigenous to the Northwest, and is a quality speedily acquired by imported plants—a point not only in agriculture, but a pretty fact for the evolutionist to ruminate upon.

Furthermore, the cool moist spring checks an undue luxuriance of stem, and allows the strength of the grain-plant to be expended on the head and fruit (that is the grain) which is what the prairie cultivator, unsolicitous in regard to manure, seeks to perfect. This vigor given to vegetation in cold climates is in accordance with the well formulated law that cultivated plants yield their greatest product near the northernmost limit at which they will grow. Rice and cotton are tropical plants, yet the products

of both these plants in Georgia and South Carolina, almost at the northern limit of their range, stand first in commercial rank in their respective markets. Indian corn, or maize, is sub-tropical, and in the West Indies grows to a height of 30 feet, but bears only a few stunted seeds, instead of the 125 bushels to the acre sometimes gathered in New York state, where the stalks are hardly one-eighth as high; while the first prize for number of kernels and general perfection was given to corn grown last year near Winnipeg, in competition with the whole of the United States. The potato, indigenous to the equatorial zone, becomes really good only in the temperate zone, and finest of all in the more northerly localities. The Northwest can beat the world in its potatoes and tuberous vegetables generally—another outrage on poor Ireland!

As for wheat—everyone interested in these matters ought to read the remarkable facts stated by Mr. J. W. Taylor, U.S. Consul at Winnipeg, in his numerous writings and speeches on this subject. Here again it is along the northern part of its range that the best product is obtained. The finest wheat grown in Europe comes from the Baltic shores; and in the United States from Minnesota and Dakota; and in this important grain we have our most striking example of what the climate of the Canadian West is in relation to agriculture. In southern Minnesota, Iowa, etc., more than two well-formed grains of wheat are seldom found in each cluster or fascicle forming one of the rows in a head In Manitoba and Assiniboia (where the shortness of the straw is surprising to a stranger), *three* grains are habitually found. This is an addition of one-third to the yield of each acre. That means 30 bushels on the average instead of 20—$15 instead of $10 an acre at present prices. But wheat grown along Peace River often shows four and five grains in the cluster!

This is not the whole of the story. The kernels are harder and better filled out than southward; and it is an established fact that varities of wheat classed as "soft" in the Mississippi states regain their flinty texture and become "hard" in the Northwest.

During May, June and July rain, generally in the form of thunder-showers, is of almost daily occurrence; so that there is no lack of moisture for the sustenance of the growing crops, just when they need it most. This diminishes toward the west, however, and when the plateau beyond the *Coteau de Missouri*, with an elevation of 3,000, is reached, summer showers are less frequent and certain. Even here, however, it is quite sufficient, as experience shows, until the very foot-hills of the Rockies are approached, when irrigation becomes necessary to success in farming. Over the great mass of the tillable prairies, however, drought causes no apprehension; and there is a belief abroad that as wire fences, railway lines, buildings and other lightning conductors spread over the plains, a greater electric equilibrium will be maintained, and rain will tend to fall more frequently and equably than heretofore.

After the middle of July rains are few, and during harvest cease altogether. This is another marked advantage over our eastern provinces, where farmers have to contend with wet harvest-weather nearly every year.

Harvest begins by the first of August, and is uninterrupted. Hay has been been stacked in the open air quite unprotected, for the farmer is sure that no deluging rains will fall upon, nor melting snows sink into it, to wash out its juices or mildew it underneath. The grain is stacked uncovered in the fields and threshed in the open air without fear of harm through dampness. You will see everywhere small stables for stock, some small granaries, and cellars for keeping vegetables; but hardly ever a barn for storing hay, straw or grain. The climate renders it unnecessary.

Over the whole of Canada's great west the climate is equally favorable for live-stock. As is is usual in northerly regions, the grasses are of the best, and by reason of the absence of fall rains and wet winter snows, they dry up on the stalk—are cured into real hay as they stand, instead of rotting; and their nutritious juices are never washed out of them. Horses, cattle and sheep fatten on this prairie grass as well as upon the richest meadows of Ontario, and cows

give an extraordinary quantity of milk, while the dryness of the air and ground is especially favorable to sheep as well as cattle.

How the Canadian plains, in spite of their interior and northerly situation, come to have so warm and dry a climate is worthy a moment's consideration, though the instruction which this audience has already received from Professor McCleod, makes any remarks from me hardly needful. It is to be remembered that south of western Canada lies the vast plains-country of the United States, an arid space thousands of square miles in extent, towards which blow steadily the warm currents of air from the Gulf of Mexico, attracted by the heated air issuing from these ample spaces of treeless land. The ground becomes baked, and the air, heated by contact with it, rises rarified in enormous volumes, sucking in the northward-bound currents to take its place, and at the same time buoying them up and preventing the condensation or precipitation of moisture. This overflow of heated air continually drifts polewards, or northward, where, it must not be forgotten, the land is far lower; and as it goes it is joined by similar currents from the Nevada and Idaho deserts, and from the coast of California and Oregon. Combined, this current pours steadily northward, attracted by the rarified air now rising from the Canadian plains, and still bearing a large part of its original moisture.

But over the Saskatchewan valley it meets the cooler air flowing from the north, also attracted by the heated prairies, and in contact with this cooling current the moisture of the south and west winds is condensed into clouds and falls as rain. A secondary characteristic of this movement is the diversion of the northward-blowing wind eastward, although, as the earlier lecturers in this Course have shown us, the natural tendency of these antitrades is toward the west.

But as winter approaches the conditions are altered. The cooling of the plains diminishes their attractive power, and the warm southerly winds tend away from the east, toward

the west, in accordance with cosmic laws. Down from the north come the cold and dry winds, unchecked by any obstacle, and the hot breath of Eolus is overcome by a frosty blast from Boréas' cold cheeks. How remarkably different would be the climate of Manitoba were there a high range of mountains between it and Hudson's Bay; or were the Saskatchewan occupied by an extensive inland sea!

It appears, then, that (apart from the influence of the Chinook, due to the presence of the Rocky Mountains) the reason the Canadian Northwest enjoys so warm and comparatively rainy a climate is, in a word, because it lies northward of arid plains of much higher elevation.

In this same condition seems to be found the valuable immunity which western Canada, and the northern border of United States enjoy from those fearful blizzards that devastate southern Dakota, and make cattle and cattlemen shiver even on the coast of Texas. These winds all come from the far Northwest, and have blown, perhaps, a thousand miles across Canada before they become blizzards. But their course over the Saskatchewan, Qu'Appelle and Assiniboine plains, and down the Winnipeg valley, is continually impeded. First, the country is everywhere uneven and often broken by respectable hills; second, large areas of it are covered with a scrub of bushes, or dotted with copses of trees, all of which check and divert the gale; third, these winds are moving steadily up grade, and their speed is as continuously checked by friction against the earth, as is that of a railway train climbing a gradient. A wind will blow down hill faster than up, just as a stone will roll down hill easier than it can be pushed up. Finally, the air in the north is so nearly the temperature of the gale that it is not sucked forward with greatly accelerated speed, until it nears the warmer latitudes where more heated and rarified air is rising from the more southerly plains, and this cold northern air is drawn in to fill the vacuum. But by the time the "norther" has reached Nebraska it finds itself blowing across plateau-lands, at the top of the hill, where there is not a bush nor tree nor range of hills to check it, and the

vacuum is close in front. It has been a respectable wind in the Northwest; a terrible gale in Montana; in southern Dakota and Nebraska it becomes a death-dealing blizzard. Poor Nebraska and Dakota must always expect them; grateful Assiniboia and Alberta need never fear them. As for the Red River Valley region, its situation makes it subject occasionally to a very respectable imitation of a regular blizzard; but this is a far rarer and less severe visitation than in Minnesota, south of it.

How do the people who live in the North-west like this climate? They universally praise it and laud especially its healthfulness. They speak of it as extremely stimulating and conducive to good spirits and courage.

The secret of this is its dryness. The atmosphere is bright, and when in winter it is very cold there is seldom any wind. Let a man take ordinary care of himself, and he will live longer and grow stronger on these prairies than anywhere else in the world.

A peculiar exhilaration of body and soul belongs to the climate, especially in and about the Rockies, which is the choicest of regions for camping excursions and sporting trips. "No man should desire a soft life," wrote King Alfred the Great, but "roughing it," within reasonable grounds, is the marrow of a visit to the Rockies. What a pungent and wholesome savor to the taste there is in the very phrase. The zest with which one goes about an expedition of any kind in the Rocky Mountains is phenomenal in itself; I despair of making it credited by inexperienced lowlanders. We are told that the joys of Paradise will not only be greater than earthly pleasures, but that they will be still further magnified by our increased spiritual sensitiveness to the "good times" of Heaven. Well, in the same way, the senses are so quickened by the clear, vivifying climate of the western uplands in summer, that an outdoor life is tenfold more pleasurable there than it could be in the east. And then, one's *sleep* in the crisp air, after the fatigues of the day, is sound and serene. You awake at daylight, perhaps, readjust your camp-blankets, and want,

again, to sleep. The sun may pour forth from the "golden window of the East," and flood the world with limpid light; the stars may pale and the jet of the midnight sky be diluted to that pale and perfect *morning* blue, into which you gaze to immeasurable depth; the air may become a pervading champagne, dry and delicate, every draught of which tingles the lungs and spurs the blood along the veins with joyous speed; the landscape may woo the eye with airy undulations of prairie or snow-pointed pinnacles lifted sharply against the azure; yet sleep claims you. That very quality of the atmosphere which contributes to all this beauty and makes it so delicious to be awake, makes it equally blessed to slumber. Lying there in the open air, breathing the pure elixir of the untainted mountains, you come to think even the confinement of a flapping tent oppressive, and the ventilation of a sheltering spruce-bough bad.

Notes on Fossils from the Utica Formation at Point-à-Pic, Murray River, Murray Bay (Que.), Canada.

By Henry M. Ami, M.A., F.G.S.

Whilst preparing my paper "On the Utica Formation and its fossils in Canada" for the Royal Society meeting of last spring, a very interesting though small collection of fossils was kindly placed at my disposal by Mr. Walter F. Ferrier, who had obtained the same in the black bituminous shales which crop out along the shore on the Murray River near its mouth, holding a fauna pre-eminently Utica in its *facies*.

The numerous and interesting geological features of Murray Bay and its environs have in years gone by received much attention and elicited careful study at the hands of geologists, notably Sir William Dawson, Dr. Harrington, members of the Geological Survey staff, and others whose contributions form a valuable series of articles in the *Cana-*

dian Naturalist and elsewhere. (See Dawson in Can. Nat., vol. vi., p. 138, *et al. loc.*)

In the "Geology of Canada, 1863," the geology of that district is sketched out carefully with the accumulated evidence at the disposal of the writer (Sir Wm. Logan) at that time, but neither here nor elsewhere have I been able to find any record made of the occurrence of rocks belonging to the Utica formation at Murray Bay. This is my only plea for the present notes, which are hereby submitted as a humble contribution to the knowledge of the geological history of the locality in question.

From the papers already published, and the lists of fossils therein contained, both the Bird's Eye and Black River and the Trenton formations are known to be well developed and easily recognized among the Cambro-Silurian or Ordovician strata of Murray Bay.

Sir William Dawson has recorded the occurrence of *Ambonychia radiata* (Hall) along with species indicating a lower horizon than that species, but its presence may certainly point to the development of strata of less antiquity than the Trenton formation in that district, most of which have been long since removed, either (?) by glacial action or by other denuding agencies at work everywhere. No distinction has as yet been made here, I believe, between the Trenton measures holding a characteristic fauna and the Utica formation, which holds a fauna very similar to the rocks ofthe same age at Ottawa, Whitby, Collingwood, and other places where that formation is developed.

From these shales, which are black, bituminous, somewhat indurated and calcareous at times, holding numerous organic remains, the following species of fossils were obtained in a tolerably good state of preservation :

RHABDOPHORA.

1. Diplograptus sp. (resembling D. pristis, Hisinger).

POLYZOA.

2. Pachydictya sp.

BRACHIOPODA.

3. Leptobolus insignis, Hall.
4. Siphonotreta, sp.
5. Leptæna sericea, Sowerby.
6. Orthis testudinaria, Dalman, *var.*

CEPHALOPODA.

7. Trocholites ammonius, Conrad.
8. Endoceras proteiforme, Hall.

TRILOBITA.

9. Triarthrus sp. (?)
10. Calymene senaria, Conrad.

OSTRACODA.

11. Leperditia (Primitia) cylindrica, Hall.
12. " " probably n. sp.

NOTES ON THE ABOVE FOSSILS.

RHABDOPHORA.

1. DIPLOGRAPTUS sp.—A few broken and imperfectly preserved stipes of a diprionidian, or petaloid graptolite, whose specific relations cannot satisfactorily be ascertained with the specimens before me.

POLYZOA.

2. PACHYDICTYA sp.—Several fronds of a species of this genus, or of a very closely related one, occur in the collection. They exhibit a considerably wide nonporiferous margin. The form in question may possibly fall under one of Mr. E. O. Ulrich's species, but which is not as yet definitely ascertained.

BRACHIOPODA.

3. LEPTOBOLUS INSIGNIS, Hall.—This species occurs in tolerable abundance in the collection, and is well preserved.

It is eminently characteristic of the Utica wherever that formation has been traced in its natural position overlying the Trenton formation in Canada and the United States; so that its presence at Murray Bay affords good evidence upon which to determine the geological horizon. The specimens from Murray Bay exhibit the radiating lines very well, showing no appreciable variation compared with Ottawa or Collingwood specimens.

4. Siphonotreta sp.—This is undoubtedly the most interesting and rarest form in the collection. A cursory examination of this form and the associated specimens was made some three years ago, but at that time it was considered and grouped along with the specimens of *Leptobolus insignis;* but a closer examination having been made last spring, it was found that the surface of the shell and other parts presented all the essential characters of a true *Siphonotreta* (de Verneuil). The specimen is preserved as a mould or cast of the shell, exhibiting the spines all around the outer margin and sides, and may possibly be a young individual of, or closely related to, *Siphonotreta Scotica* Davidson, a species recorded by Mr. J. F. Whiteaves in 1883 from the Utica formation in a paper read by him at the Montreal meeting of the A. A. A. S. Additional notes on that species were made by the writer in the "Ottawa Naturalist" for December, 1887, and in Vol. II. No. 3 of the Ottawa Field Naturalists' Club Transactions, No. 7, p. 347. The following notes are taken from the Murray Bay specimen, which is probably the larger value: Dimensions as follows:—*Length* of the shell, 1·75 millimetres; breadth, 1·8 millimetres; length of the setaceous spines in front, ·5 millimetre.

This minute form agrees very well with the characters such as a young form of Siphonotreta Scotica, Davidson, and its Canadian variety might assume or be expected to have from an examination made of many adult individuals collected in the Utica of Gloucester, near Ottawa, but there is also a very close resemblance between the Murray Bay

specimen and the *Siphonotreta micula* described by Prof. McCoy[1] from the Llandeilo rocks of Great Britain, and which he himself recognized afterwards in rocks of similar age in Australia. Dr. Bigsby, in his "Thesaurus Siluricus," states that *S. micula*, McCoy, occurs in Meath, Ireland, England and S. W. Scotland, at Glenkiln, Dumfrieshire, and in several localities in Wales. The Murray Bay specimen differs from *S. micula* in having the concentric lines of growth or striæ more distant, there being only *twelve* in the space of one millimetre, whilst there are are said to *seventeen* in the same space in the latter. The spines, again, are comparatively longer in the Murray Bay form than in *S. Scotica*, but much more numerous than in *S. micula*. They are exceedingly slender and smooth. The specific relations of this form require better specimens before definite conclusions are arrived at.

5. Leptæna sericea, Sowerby.—Only a fragment of what appears to be this ubiquitous and common species occurs in the collection.

6. Orthis testudinaria, Dalman, var.—This species of Orthis resembles one which is found in tolerable abundance in the limestones at the foot of the Montmorency Falls, near Quebec. It is here provisionally referred as a variety of *Orthis testudinaria*, though there is good reason for a different specific designation. The costæ, especially about the beak and along the anterior margin, differ considerably as to their arrangement and distribution.

Cephalopoda.

7. Trocholites ammonius, Conrad.—The mode of occurrence, preservation and characters of the specimen referred to this species agree perfectly with the numerous individuals occurring in the Utica shales of Whitby, Ottawa and Collingwood.

[1] British Palæozoic Fossils, pp. 188 and 189; Pl. 1 H. fig. 3.

8. Endoceras proteiforme, Hall.—As is usually the case, with nearly all the specimens collected of this species in the Utica, the shells are flattened and broken, showing that it was exceedingly thin and brittle. There are four cepta in the space of 3·5 centimetres.

Trilobita and Ostracoda.

The trilobites and bivalved crustaceans mentioned in the list (*supra*) have been determined with as much accuracy as the state of preservation of the specimens warrants. When more specimens are obtained, and some more perfect ones than those before me, the relations, both generic and specific, may be changed, and a number of additional species recorded from that outcrop of the Utica at Murray Bay.

It may not be deemed out of place here to point out the entire absence of those species of fossils which characterize the so-called Utica shales along the south shore of the St. Lawrence, and on the northern side of the Island of Orleans. The geological horizon indicated by the fossils contained in this brief note is evidently that of the Utica formation. Nearly every species mentioned occurs in that formation at Ottawa and Whitby, in Ontario; so that the exposures of this formation at Murray Bay may be said to be the most easterly outcrop visible of the Utica on the north shore of the St. Lawrence.

The Relation of Climate to Vegetation.[1]

By D. P. Penhallow.

In conformity with the laws of Natural Selection, as stated by Darwin and accepted by modern biologists, conditions of environment are the determining factors in the growth, character and distribution of organic life. These conditions are nowhere uniform, and present numberless gradations and complications, in consequence of which organic life possesses characteristics which are everywhere subject to more or less striking variations; and if we are to form a correct estimate of the relations between cause and effect, it is essential that we first inquire into the specific influence upon functional activity of each one of the elements which, in the aggregate, constitute the environment of any individual or species.

Among these conditions we may note those of food supply and nutrition; varying intensity and quality of light; moisture; pressure; electricity; the presence or absence of certain gases and temperature; and in this latter element is found one of the most important of all the factors which determine the normal life of a plant. We are well aware that certain plants are found growing in hot springs at a temperature of 199.4° F. or within 12.6° of the boiling point of water, thus representing in modern times, although in exaggerated form, conditions under which, in the later Laurentian age; primitive vegetation very generally flourished. Other plants—the red snow—are found to complete their existence at a temperature so near the freezing point of water that the difference cannot be measured. But in each case the plant is equally sensitive to extremes of an opposite nature and would perish miserably were the temperature to be sensibly lowered in the one case or raised in the other. Between these two extremes, the majority of plants flourish at a much more moderate temperature, nevertheless, it is a well defined law of nature that each species thrives best at

[1] Abstract of a lecture delivered in the Somerville Course, at Montreal, March 1st, 1888.

a specific temperature, to which it is specially adapted. The seeds of wheat and barley will not germinate below 41° F., while they grow more rapidly at 83.6° F., and cease all further growth beyond 108.5° F. Corn will not germinate below 48° F.; its vegetation becomes most vigorous at 92.6° F., but ceases when the temperature exceeds 115° F. The squash seed demands at least 56.6° F., attains its best growth at 92.6° F., and beyond a superior limit of 115° F. its existence ceases. We thus find that the total range of temperature, between the superior and inferior limits, under which the life of wheat and barley can be accomplished, is 67.5° F. For corn, 67° F. and for the squash 58.4° F. From these simple facts, which might readily be extended to other species, we learn that each plant not only requires a certain degree of heat for the completion of its normal functions—a degree which varies with the species or with the type—but that the extremes of temperature which a plant can successfully withstand, may be much greater in some cases than in others. And also that when all the energies of the organism are dormant, it is in that condition best adapted to its resisting these extremes, especially of low temperature. Thus in our own locality, trees which, in the month of August, flourish under a mean temperature of 67.5° F., sometimes subjected to a maximum of 91°, still exist without apparent injury, when in January or February, they encounter a mean 6.8° F., and a possible minimum of 26° below zero, thus giving an extreme range of 117° F. We are aware, however, that as we approach the equator, the extremes are greatly reduced and the general conditions under which vegetation flourishes, become much more uniform.

From this we perceive that when the conditions of environment are of an unusual character, the organism must be affected in one or more of its functions, with a constant tendency towards permanency of variation according to the strength and duration of the modifying influences. It is true that the conditions to which any organism may be subjected—as in transfering a plant from an equatorial to a north

temperate region—may be of so unusual and extreme a nature as to absolutely limit its existence. On the other hand, it is equally true that if the same conditions are applied with less energy for a given time, and thus the sum total of the modifying influences is extended over a much greater period, the organism not only becomes gradually adapted to its new conditions of life, but under their influence may even become permanently modified in one or more essential characteristics. This is a matter of common observation with those who are familiar with plant life, and such variations may be accomplished so rapidly as to be recognisable within the lifetime of a given observer. Thus it is well known that plants grown in botanic gardens, become so modified by their unusual conditions of life, that they no longer answer in a strictly scientific sense, to the description of the species in the original wild state. Similar variations are to be noted among wild plants as their surroundings vary. The same species growing under different conditions of moisture, as in wet and dry places, will present important differences in size, color and form ; or growing at different elevations, and thus under somewhat widely different conditions of temperature and pressure, its general aspect becomes wholly changed.

It is thus not difficult for us to appreciate the fact that since climate involves many of the factors already enumerated, and especially temperature, it as a whole, must exert a preponderating influence upon plant life, not only to determine its character in a given locality, but also the range of distribution for various species. With these general principles in mind, we are prepared to examine and understand some of the relations known to exist between climate and vegetation, which constitutes the subject of our lecture this evening.

Of the various important problems with which modern botanical science has to deal, that which is concerned in determining the relations between climate and vegetation is perhaps one of the most intricate and far-reaching.

Climatic conditions mean, primarily, temperature and

moisture; but these in turn are variously modified by elevation, pressure and latitude, as well as those influences which originate in the movements of air, proximity of water, ocean currents and diversified character of the great land areas. Add to all these the influence of ocean currents, winds, animals and man, in effecting a wider distribution; while we also keep in mind that those very conditions of environment, which serve to induce wider distribution in some species, are the limiting conditions for other species, and some conception may be formed of the peculiarly complicated nature of the problem before us.

But if climate directly influences vegetation, it is also true, though in a much more restricted sense, that vegetation exerts a counter influence upon climate, with a tendency to modify it in more than an important respect. This will be found to hold true, chiefly, in plants of arborescent form, and instead of affecting wide areas, the influence is usually of a mere local nature. While, therefore, less direct and certainly far less potent, the effect of vegetation on climate is felt in the purity of the air; its relative humidity and consequently its temperature, local rainfall, and even upon the air, as a medium for the distribution of septic organism. At the same time, many of these effects, either positive or negative, are to a large extent susceptible of control at the hands of man. The changes which he effects in the vegetation of a given district, either through ignorant waste or to meet actual requirements, find their final expression in their climatic influence. This fact is so well attested, not only by our present experience, but by the history of the world for centuries, that it needs no special argument at this time to enforce it upon our attention.

As the influences already referred to are by no means uniformly distributed over the surface of the earth, which is also variously modified as to surface and geological character, there are found large areas between which extreme variations occur, in consequence of which there is a corresponding inequality in the distribution of vegetation. From

this we perceive that while a study of climate will enable us to pretty accurately determine the character of the vegetation for a given area, conversely, the critical examination of a given flora will enable us to arrive at tolerably exact conclusions relative to the climatic conditions under which it flourishes. Therefore, while geographical botany enables us to solve many questions of importance so far as the present is concerned, it renders it possible, by comparing similar types of the present and the past, to accurately determine the climatic conditions which must have obtained in the various geological periods since vegetation first made its appearance. And finally, we may note that, as plants are influenced in their distribution, so will their regularity of development depend upon uniformity of climatic condition—periodicity in the latter enforcing periodicity in the former.

In instituting inquiries of the nature of those with which we are now dealing, we first of all naturally seek information respecting the number of plants known to man. Botanists in all parts of the world are bringing hitherto unknown species to our knowledge, and in some of the more imperfectly explored parts of the globe, the number thus constantly added is very considerable. It will therefore appear that we are wholly unable at the present time to make any exact statement relative to the number of existing species. Meyen in 1846, estimated the whole number of species at somewhat more than 200,000. Duchartre's estimate places the figure between 150,000 and 200,000, while De Candolle and Gray estimate somewhat more than 120,000 species of flowering plants alone.

But the distribution of this enormous number of plants is nowhere uniform. Each species or genus has its centre of distribution where the number of individuals is greatest, from which there is a more or less rapid diminution in all directions until the extreme limits are reached. This law may be illustrated in our own flora. Of the North American oaks, there are thirty-six species. These have their centre of distribution within a narrow radius centering upon

the junction of the Ohio and Mississippi rivers. There at least fourteen species are found. If we now move northward, we find that a line passing through central New York, northern Pennsylvania and central Ohio, marks the limits of ten species. A line extending from central Massachusetts through the centre of Lake Ontario, touching the southern extremity of Lake Huron and thence into southern Wisconsin, marks the northern limit of eight species. Four species extend as far north as Montreal, and two to Quebec, while only one species extends a few miles further, and thus reaches the extreme northern limits of distribution.

The tulip tree has its center of distribution in Kentucky, Western Virginia and the eastern half of Tennessee. Its extreme limits reach southward, almost to the Gulf of Mexico, westward to the Mississippi, eastward to the Atlantic, and northward to the Great Lakes, finding their termination just within the Dominion, along the northern shores of Lake Erie.

This law of distribution was fully recognized by the elder Michaux who, 102 years ago, undertook to determine the centres of distribution for all our North American trees, a task which led him over the greater part of the United States and Canada, and resulted in one of the most important contributions to American botany prior to this century.

Distribution of different species over a common area and therefore under similar conditions, constitutes a flora. Between one floura and another, there are no sharply dividing lines—each merges more or less into the other by insensible degrees, yet each is distinguished by certain prevailing forms. It therefore follows from what has thus far been stated, that any division, in point of distribution, of the vegetation which covers the surface of the earth, must be based upon purely arbitrary considerations.

Recognising these laws, Grisebach divides the surface of the earth into twenty-four great regions, each of which is distinguished by the characteristic or most prevalent forms of plant life, together with the part of the world in which it lies.

On this continent alone, there are wholly or in part, six distinct regions of vegetation, but in certain of these, at least, we note that the greatest range is from north to south, in consequence of which plants of widely different type and habits must be included in one common flora. Thus in the North American Forest Region, the flora of that portion lying north of the St. Lawrence and the Great Lakes is characterised bysuch trees as the white pine, spruce, hemlock, willows, birches and poplars; while such types as the oak, walnut, magnolias, chestnuts and long leaved pines, belong to the southern portions; the connection between these two groups being established through the maples, beeches and elms.

We may now direct our attention to another mode of division based upon temperature and variations in type.

If a person were to commence a journey at the equator, and follow due north until he reached the Pole, certain important facts—changes in the character of the vegetation—would force themselves upon his attention and demand explanation, however unobservant he might be. Starting in a region of richly luxuriant vegetation, remarkable for its great variety of forms, rich foliage, brilliantly colored flowers, as well as the rapid growth and often great size of all forms of plant life, he would by almost imperceptible gradations, find all these characteristics changing, until, on reaching the Arctic Regions, he would discover himself landed in a waste devoid of trees, bearing but scanty specimens of woody plants, which, instead of holding themselves proudly aloft, would be found trailing close along the ground or stunted into a most unseemly condition. Lichen covered rocks and moss grown fields would everywhere present the characteristic forms of plant life, while here and there, between the rocks, dwarfed herbs would rear their disproportionately large and abundant flowers, to catch the scant blessings of an altogether too brief existence. From a region where all nature seems to glory in existence, where plants appear in their greatest number and variety, and life is a perpetual joy, our traveller has passed to another region

where variety and number are reduced to a minimum, and life appears to be one continual protest against the conditions imposed upon it.

The inquiring mind at once asks what produces this marvellous charge? To this the answer as naturally comes that, with an increased obliquity in the sun's rays as they strike the surface of the earth, there must be corresponding variation in the absorption and radiation of heat, and hence a lower temperature in the surrounding atmosphere. The climate has therefore changed with the progress of our traveller, and with it the vegetation of the various latitudes through which he has passed.

We therefore find that botanists are in the habit of dividing the surface of the earth into a certain number of regions or zones, between the equator and the pole, as determined by the most characteristic changes in climate and vegetation; and that this offers a somewhat more rational and convenient division than that proposed by Grisebach, is apparent. Those zones, therefore, with their corresponding mean temperatures, are as follows:—

The equatorial zone extending to lat. 15° N. with a mean temperature of 26° 30° C. Here the extreme heat, combined with a high degree of atmospheric humidity, calls forth the most luxuriant vegetation, such as impresses the reflecting mind in the most profound manner. Palms, bananas, rich orchids, luxuriant ferns and gigantic fig trees, over and among which swing enormous vines, give a peculiar character to the region, and bear witness to the highly favorable conditions under which organic life has its development.

The tropical zone, reaching from 15° lat. to the limit of the tropics, has a mean temperature of 23°-26° C. Here we meet with great variations in temperature. In summer, the mercury often exceed 30° C, while in winter it sometimes descends below the freezing point. Monsoons also constitute one of the characteristic features of the climate. Here we also meet with the palms, bananas and orchids; but the tree ferns and fig are the characteristic types.

The sub-tropical zone reaches from the tropics to 34° of lat., with a mean temperature ranging from 17°-21° C. We now meet with a vegetation in which evergreens prevail, and the myrtle and the laurel mark the type of the flora. At the same time, the high summer temperature induces the growth of annuals which properly belong to the tropical zone.

The warm temperate zone embraces the regions between 34° and 45° lat., with a mean temperature of 12°-17° C. Here we find the oak, chesnut, walnut, magnolias; while leguminous plants and the various grains flourish extensively.

The cold temperate zone includes a belt lying between 45° and 58° lat., with a temperature ranging from 6°-12° C. Here the prevailing forms of vegetation appear in the conifers, birches, maples, the heathers and junipers; while the rocks and trees are distinguished by an abundant growth of lichens, and mosses are everywhere abundant.

The sub-arctic zone, extending from 58°-66° lat., with a mean temperature varying from 4°-6° C., is much more restricted than the former, and its limits are not always clearly defined. Here the pines appear only along the southern border, and the poplar, birch and juniper give character to the region. Lichens and mosses are more abundant.

The Arctic region reaches from 66°-72° lat., with a mean temperature of about 2° C.=36° F. The prevailing tree here is the birch. Herbaceous plants are small, and their flowers disproportionately large and numerous. Lichens and mosses prevail.

In the Polar zone, herbaceous plants are rare, and even small bushes are wanting. The surface of the earth, during the short season when the snow is removed, is everywhere characterized by the extreme poverty of its vegetation. Beyond this is the Polar limit of perpetual snow.

If now we return to the equator and ascend a high mountain, with increasing altitude we pass through regions where the vegetation successively changes, until we ultimately reach the line of perpetual snow.

Thus at the plain we begin with the region of palms and bananas; at 1900 feet pass into the region of the tree fern and fig; 3800 feet brings us to the region of myrtles and laurels; at 5700 feet we encounter the evergreen dicotyledonous trees; at 7600 feet, the region of deciduous trees; 9500 feet, the region of spruces; 11,400 feet, the region of rhododendrons; 13,300 feet, we enter the region of Alpine plants, and at 15,200 feet encounter the snow limit.

We thus find that there are eight distinct regions, both with reference to latitude and altitude, in which corresponding forms of plant life occur, whence it appears that both increasing elevation and increasing latitude, through diminishing temperature, exert the same influence upon plant life.

Were the surface of the earth everywhere uniform, and no other modifying influence felt, the distribution of plants would also be tolerably uniform within the limits thus assigned; but even within the same line of latitude, great variations are to be noted both in climate and vegetation. Temperature decreases at the rate of 1° for every 200 or 400 feet of elevation, and were the surface of the earth sufficiently uniform, there would be a regular variation in vegetation and definite limitation of plant life with increase of elevation. But on steep mountain slopes, less heat will be absorbed and radiated into the surrounding air than upon plateaus even at a much greater elevation, whence it follows that plants which are confined to a relatively low elevation in the first case, become abundant at much higher altitudes in the second case. This affords an explanation, therefore, of the well known occurrence of certain plants at unusual elevations.

This fact finds a familiar illustration in the progress of vegetation on the slopes of mountains, where the same species extend from the plain, for some distance up the slope. As spring approaches, the plants on the plain will be found to come into bloom first, but as the season advances, the same species will come into bloom at successively later periods of one or more days, corresponding to difference in elevation.

Another fact that may be noted in this connection, is that plants of a more southern type not infrequently ascend to higher latitudes, and thus occur beyond the general limit of distribution for the species as a whole. This finds its explanation in part in the fact already cited, that great plateaus have a somewhat higher temperature than isolated mountains at the same elevation, but it is also to be referred in part to other causes. Such northern extensions of a flora will be found to be accomplished under the protecting influence of large bodies of water, which secure a more equable temperature, and tend to produce a somewhat higher annual mean than in more remote parts in the same latitude and at the same elevation above sea level. Warm ocean currents have a similar effect, and often produce the most striking modifications in the climate and vegetation of the shores they wash.

In the Atlantic, the Gulf Stream sweeps along the coast of Newfoundland, and reaches across to the northern shores of Great Britain, and even of Norway, giving to the former a climate whose mean annual temperature is that of New York, and a vegetation which, on this continent, flourishes only at several degrees lower latitude.

But if it is possible for such northern extensions of a flora to be made under special conditions, it is equally true that southern extensions of northern floras are possible. A notable instance of this is found in the arctic plants which, under the influence of the polar current reaching southward out of Baffin's Bay, extend along the coast of Labrador and into the Gulf of St. Lawrence along its northern shores, thus intruding an arctic flora into the north temperate flora.

As, however, an increase of temperature is, in general, more favorable to vegetation, it is found that plants more readily extend southward and adapt themselves to the conditions they there find, than in the opposite direction. Or to state it in a more practical way, plants may be transplanted from a northern to a more southern region, with far greater assurance of successful acclimatisation, than if

carried in the opposite direction, the adverse influence of cold being far greater than that of heat, within the same limits. In all such cases of forced or natural migration, the species undergoes more or less striking and rapid modification. Thus the alpine plant carried to a lower latitude or elevation, gradually loses its dwarf habits of growth and ultimately becomes indistinguishable from the plants native to the region. On the other hand, southern plants, when carried north, if they survive the cold of winter, grow more slowly and fail to attain their former height. It more frequently happens, however, especially when the difference in latitude is great, that the plant experiences important changes in other respects. This finds a striking illustration in the castor oil plant so commonly grown here on the lawn. A tropical plant by nature, it is in its usual habitat a perennial, which not only becomes woody, but attains the form and dimensions of a tree. Planted in this latitude, it at once becomes reduced in size, rarely exceeds six or eight feet in height, and remains essentially an herbaceous plant, limited in its growth to one season.

On the other hand, the heat of summer, even in so high a latitude as this, is sufficient to bring to maturity many sub-tropical plants like the squash, melon and cucumber, which supply much needed variety to our diet. We thus learn that plants which, through natural means of distribution, would find it impossible to reach high northern limits, on account of the extremely low temperature to be endured at certain seasons of the year, may nevertheless, through the agency of man, who plants the seed at the return of each spring, be maintained at very high latitudes or altitudes. The influence of extreme temperature thus indicated, is apparently a determining factor in the distribution of plants, but this can only be regarded as true when such extremes are severe and of long duration.

Recognizing these facts, it is generally considered by botanists that the distribution of plants as a whole, is not determined by the extremes of temperature, but by the annual means. And if we follow the lines of distribution

for any species, we will find them conforming to those lines of equal temperature which Humboldt designated isothermal. It is therefore easy to understand that the migration of plants is accomplished with the greatest difficulty in direction of latitude, but that it becomes a comparatively simple matter for them to extend in direction of longitude, It is a recognition of these laws which should guide us whenever we desire to introduce exotic plants for the adornment of our grounds, or to add new resources to our food or forest supply.

These laws are also expressed in the germination and growth of plants. It is a well recognized law of vegetable physiology, that while a certain temperature is essential to the germination of seeds, the requisite degree of heat is not the same for all plants, and in fact often differs widely. The same may be regarded as true of growth after germination. We may therefore indicate the lowest temperature at which germination can begin, and also the best temperature for growth as follows :—

	Germ.	Best Growth.
Wheat and barley	41° F.	83.6°
Pease	43.5°	79.9°
Corn	48.0°	92.6°
Beans	48.0°	92.6°
Squash	56.6°	92.6°

Such facts as these are significant and could readily be made to apply to all plants.

A very interesting, and in some respects important effect of climate upon vegetation, and more especially upon the arboreal forms, is to be seen in the correspondence between climatic periodicity, and periodicity in growth with corresponding modification of structure.

An examination in cross section, of any of our common trees such as the maple or elm, will show that the woody trunk is built up of a series of concentric rings, and if we follow the growth of such a tree from year to year, it will appear that these rings coincide more or less closely with the alternation of seasons, one ring for each year, in conse-

quence of which they are usually designated as the annual rings. Advantage has been taken of this fact to reach an approximate estimate of the age of trees such as the great redwoods and sequoias of California, and it becomes of practical value to the surveyer in re-establishing old boundary lines.

In order, however, to correctly determine their relation to climatic influences, a few important considerations may be passed in review.

The formation of such rings or layers of growth, is referable to periods of physiological rest and activity, which alternate with one another, together with the secondary influence of internal tension established between the wood and bark. Whenever the change of seasons is sharply defined, and the conditions which obtain during summer are favorable to continuous growth, there will be but one period of activity and one of rest; consequently, but one layer of wood for a given year. There are notable exceptions to this, however. The red maple has been known to form several such rings in one season, and the same is true of other plants, but many such cases find at least a partial explanation in the attendant conditions, which induce repeated periodicity within the same season. In the tropics, where the conditions for continuous growth are more favorable, trees generally exhibit no rings whatever, and when they are developed, an explanation is usually to be found in local conditions. We therefore learn from this, that increasing cold, through inducing a more perfectly defined periodicity in growth, causes the formation of layers of growth which, in number, correspond approximately to the age of the plant, and this correspondence will be closer, other conditions being equal, the farther north, or the more remote from the equater, the location is.

Finally, we may turn our attention to a brief consideration of those influences which vegetation is supposed to exert upon climate. The history of Southern Europe and Asia Minor, as well as the more recent history of this continent, shows that with the removal of the large forests once

covering these areas, certain pronounced changes have been effected in the frequency of rainfall and in the constancy of supply of water, as marked by the flow of rivers and small streams. It has, therefore, been a somewhat common practice to refer such changes to effect upon the total rainfall, and to ascribe to the presence or absence of abundant vegetation of the arborescent form, a definite influence upon climate. The question is of the greatest importance, as through its influence upon manufactures and water supply, as well as its effect upon tillage, it directly concerns some of the more important economic aspects of life. As at the present time, the changes referred to—de-forestation and re-forestation—are now taking place upon a large scale within the limits of the United States and Canada, we have a convenient field of observation at hand, as a basis upon which to determine how far such opinions coincide with known facts.

One of the most important functions of the plant is its power of transpiration, or its ability to liberate water from its structure in the form of aqueous vapor. Such transpiration is one of the important factors in determining the movement of water from the roots, where it has been absorbed from the soil, to the leaves, where it is utilized in the various chemical changes incident to growth. The capacity of plants in respect to this function, or the amount of water they will thus liberate within a given time, is extremely variable, though constant for any one species under uniform conditions of growth. Moreover, while many plants are structurally adapted to the freest possible transpiration, others are adapted to retardation of this function when the conditions of supply are limited, as must be the case in very hot and dry regions. In all cases, however, transpiration is controlled by conditions of light and heat, as well as by the extent to which the surrounding atmosphere is already charged with aqueous vapor.

The general tendency of this function will in all cases be to establish a constant movement of water upward from the soil through the plant, until it is liberated from the leaves,

and the younger and more active these organs are, the greater will be the volume of water transpired within a given time. Upon the same principle, plants exposing large leaf areas, which retain their activity for a long time, are much more energetic agents in effecting this transfer and conversion than those which are more woody, have a less proportional leaf area, and mature earlier.

Various investigations have from time to time been made, to determine the actual amounts transpired under different conditions. It will answer our present purpose to cite only one or two of these results. Höhnel records that in an old beech forest somewhat more than 100 years of age, the whole volume of water transpired by one hectare or 2.47 acres, during the six months from June 1st to December 1st, amounted to between 2,400,000 and 3,500,000 kilos, or from 5,291,000 to 7,716,100 pounds, which, reduced to liquid measure, would give from 529,104 to 771,610 gallons. But these figures express only a portion of the water actually withdrawn from the soil, whence we can readily understand that plants serve as a drainage system as it were, for the soil.

This fact has of recent years, been somewhat largely taken advantage of, for the purpose of draining swamp lands with a view to improving them for purposes of tillage, and to remove their influence in promoting the dissemination of malarial organisms which are formed in the presence of large quantities of decomposing organic matter. For this purpose such plants as the sunflower, with its great expanse of leaf area, from which transpiration may proceed at a rapid rate, may be used. But the Eucalyptus globulus, or the blue gum of Australia, appears to answer this purpose even more fully, and is at the present time largely employed.

The liberation of large volumes of water by a forest, as indicated above, necessarily tends to reduce the temperature of the surrounding air and to bring it nearer the point of saturation—*i.e.*, it increases the relative humidity of the atmosphere. Any general influence which tends to still

further reduce the local temperature, brings the air below the actual point of saturation and rain falls. It is therefore to be noted that forests affect precipitation in the form of rain or snow, to the extent that rains become more *frequent* in forest regions than elsewhere. This effect, then, is of a local nature, but has popularly been interpreted to mean that forests increase the total rainfall, which can hardly be regarded as true, since they do not increase the absolute amount of water in the atmosphere, but only the relative quantity. And, moreover, the weight of scientific evidence thus far available, shows that such influence is not produced. One of the most conclusive arguments bearing upon this point, is that of Mr. Henry Gannett in a recent number of *Science*. For this purpose he employs large areas in the United States where, since colonial times, deforestation and reforestation have been going on on a very large scale. The deforesting of 25,000 square miles in New England, prior to 1860, was found to be attended by an actual increase in annual rainfall. The deforesting of 40,000 square miles in Ohio was attended by an almost inappreciable diminution in rainfall, while the reforesting of 100,000 square miles of prairie in Iowa, Missouri, Minnesota and Illinois has been accompanied by a slight diminution. And Mr. Gannett's conclusion that it is useless "to discuss further the influence of forests upon rainfall from an economic point of view," is to be endorsed as essentially correct.

But the question is then pertinent, How do we account for the shrinkage of streams, the drying of springs and other changes which are known to attend the removal of forests? Southern Europe and some parts of Asia Minor have, by removal of their once abundant forests, become converted into dry wastes. The question here raised is of the greatest importance, and each year demands more serious consideration. In their report for 1885, the Forestry Commission for the State of New York, the chairman of which is no less an authority than Prof. C. S. Sargent, of Harvard University, give expression to the following views, based upon observed facts:—"The most important

function of the Adirondack forests is found in the influence which they exert upon the streams heading among the hills of the Adirondack plateau, which distribute the heavy rainfall of this region. As reservoirs of moisture, these forests are essential to the continued prosperity of the State. Their influence is felt far beyond the limits of the State, and their destruction must be followed by widespread commercial disaster. The future of the rivers which flow from the Adirondack plateau may be judged by their past. Great changes have been noticed in these streams since the area of the Adirondack forests has been materially reduced. All the testimony which the commissioners have been able to collect upon this subject, indicates that the summer flow of the Adirondack rivers has been decreasing within the memory of men now living, from thirty to fifty per cent.

These effects have a simple explanation. Any land area covered by forest has its rate of evaporation reduced by the shade thus afforded to the extent of 38 per cent., as compared with cleared lands; and the reduced evaporation under such circumstances so far exceeds the loss of water by transpiration, that there is an actual accumulation of water in the soil of forest-covered areas. Moreover, the organic matter accumulated in the growth of a forest, and the abundauce of moss induced by the moist shade thus afforded, serves as a retaining medium to hold the excess of water and allow it to gradually flow away into the streams. It follows from this, that streams rising in a dense forest will be distinguished by the uniformity of their volume and rate of flow; drought and flood are rare; springs abound. A removal of the forest destroys all the conditions upon which these phenomena depend. The stream experiences strong fluctuations in volume and rate of flow; springs disappear, and drought becomes frequent; while every rainfall is immediately precipitated down the steep hillsides, rapidly merging into a flood, which carries disaster in all directions.

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Notes on some of the Birds and Mammals of the Hudson's Bay Co's. Territories and the Arctic Coast.

By John Rae, M.D., LL.D., F.R.S., F.R.G.S., &c.

During a residence of twenty years in various parts of the Hudson's Bay Co's. Territories, embracing the extreme south of James's Bay, Hudson's Bay and north to the Arctic Sea, I had, as a sportsman, many opportunities of paying considerable attention to the habits and peculiarities of the fauna—especially birds—over a rather extensive field of observation, the result of which I shall attempt to give in the following remarks, some of which may perhaps be new, others disputed, or possibly well known.

My first ten years in this wild country were spent at Moose Factory, the Hudson's Bay Company's depot, in the southern department, lat. 51° N., long. 81° W., where the salt-marshes along the coast afford favorite feeding grounds to a great number and variety of water-fowl on their migrations to and from their breeding place in the north, and

nearly all my spare time, at these seasons, was spent in shooting and acquiring some knowledge of the peculiarities of the game I was in pursuit of. First let me say somehing of that magnificent bird, the Canada Goose (*Anser Canadensis*), one of the finest of its order in the world.

This is the earliest of the spring water-fowl migrants, and makes its appearance at Moose, with extreme regularity, on the 23rd of April. So much is this the case that during my ten years stay there, we had a goose at our mess dinner table on St. George's day, first seen and shot on that day; and this I learnt had been the case for a long series of years previously. I may add that this species of goose arrived with about equal regularity at York Factory, latitude 57° N., 420 miles further north, but a week later.

The Cree Indians, at both these places, assert positively that a small brown bird uses this goose as a convenient means of transport to the north, and that they have been often seen flying off when their aerial conveyance was either shot or shot at. The little passenger has been pointed out to me, but I have forgotten its name. Certainly it makes its appearance at the same time these geese do, which, by the way, are the only kind that are said to carry passengers. The natives of the Mackenzie River, more than a 1000 miles to the south-west, tell the same story, so I believe in its truth.

According to my experience and belief, there is another, but less numerous, variety of the Canada goose; the male of this bird is usually distinguished by a ruddy brown colour of the plumage on the breast, by the extreme loudness and sonorousness of the call, and by the so much greater size, that there is a difference made in the quantity served out as rations to the men. The line of flight of this larger variety is also different, as they pass chiefly by Rupert's River, about 100 miles to the east of Moose, and thence on to the east main coast of Hudson's Bay, on which lands they breed, not going very far north, nor crossing as far as I know, Hudson's Strait—as none are mentioned as having been seen at the Meteorological station, under Mr.

Payne, at Hubert's Bay, on the south shore of the Strait. A few are sometimes obtained at Moose, by which I had an opportunity of comparing them with the smaller and more common variety.

This *Anser Canadensis* (Major?) instead of being found feeding during its autumn visit on the low marshy shores of the bay, is seen on the higher and more rocky ground on the east coast, where its principal food is berries of various kinds.

By far the most numerous of the goose tribe that visit Moose and Albany marshes in the autumn are the snow goose (*A. hyperboreus*), and the blue wavy or blue-winged goose of Edwards. Some forty-five years ago, when I was at Moose, only the blue-winged wavy was seen at Rupert's River, and no snow geese; and it is so at the present time. About equal numbers of both kinds used of old to visit Moose, and such is the case now; but half a century ago not a single blue-winged goose was to be seen at Albany River, 100 miles north of Moose, while now they are about as numerous at the former place as the snow goose, and both are more abundant at Albany than at any other part of the west shore of Hudson's Bay. As far as I can learn, no blue-winged geese are ever seen at York Factory, latitude 57° N., nor at any of the lines of flight of the snow goose further to the west.

As these two species resemble each other in form, size, and call, but not in colour; and as they often feed together, the blue-winged was for a long time considered as the young of the white wavy, an erroneous opinion, which I endeavoured to correct, after seeing a great many of both kinds of birds.[1] I showed that the young of the snow goose was of a light grey colour, slightly darker on the head and neck, while the young of Edward's blue winged-wavy,[2] was much darker, of a bluish-grey, approaching to black on

[1] See my little book entitled "Expedition to the Polar Seas" (1846-7), published by Boone, London.

[2] The term Wavy is a corruption of the Indian word "whey-whey, an imitation of the call of the goose.

the head and neck. To prove the correctness of this, I obtained the specimens shown on the table, namely, an old and young snow goose, and an old and young blue-winged, shot in autumn on their return from breeding in the north.

In the Transactions of the Royal Society of Canada for 1882, Section IV. p. 49, there is a paper entitled "Notes on the Birds of Hudson's Bay,"[1] in which we are told that "there appears to be no doubt that the *blue-wavies are only the young of the white.*" This is, of course, a mistake, but there are other inaccuracies in the same paper. For example, it states that minick, gadwall and grey duck, are one and the same bird. The pintail, (*Dafila acuta*) is the minick, a name given to it by the Indians in imitation of its call. The long-tailed duck is called in the paper *Dafila acuta*, but this is the scientific name of the pintail. The long-tail or (Ka-ca-ca-mee) of the Indians is *F. glacialis.*

The same paper says "that in the breeding season the male of the willow grouse has the head and neck of a reddish pheasant color, with the exception of the wings, which have a good deal of white," and that in the winter the white of the living bird "has a beautifully delicate rosy tint, which forms a considerable contrast with the surrounding snow." The summer plumage resembles the plumage of the Scottish cock grouse, but the wing feathers are always white, whilst the "rosy tint" is only to be seen on fine, mild and sunny days, *never* during cold dull weather.

After this brief digression let me return to my subject. The snow and blue-winged geese have a peculiarity I have never noticed in any other species. Previous to taking their southern flight from Hudson's Bay, they are for several days almost constantly on the open sea, never feeding, but busy washing themselves, taking short and rapid flights, and apparently having a good romp and great enjoyment. They are at this time very fat, and when shot, their stomachs and intestines are found perfectly empty, resembling, I am told, in this respect, those of salmon, prior to the hard work of ascending rivers to the

[1] By R. Bell, M.D., F.G.S., &c.

spawning-beds. After this spell of fasting, ablution and athletics have been gone through, the geese are evidently prepared for their long flight of many hundreds of miles to the south. On the first favourable opportunity, which means a fresh breeze of northerly or north-westerly wind, they take wing in batches of thirty or more, circling round until they attain a safe altitude and then bearing away before the wind on about a true southerly course, never resting, I believe, until they reach winter quarters, many hundred miles distant. The Canada goose, on the contrary, stops to feed by the way, especially on the lakes in which wild rice abounds, which brings both ducks and geese to a much finer condition for the table than any other kind of food that they can obtain. Both the blue and white wavy are excellent, wholesome food, and one of these with a pound of flour or bread forms a days rations much liked by the men, especially when fresh. Many thousands are cured by salting and packed in barrels for the use of the Hudson Bay Co's. people, and the Indians of or near the coast, besides living upon them during a part of spring and autumn, "bone" and smoke-dry a great many for winter use, and also prepare much of the fat, to use with their hares or fish.

All kinds of grouse in Canada with which I am acquainted have the well known habit, during winter, of passing the night under the snow to protect themselves from the cold; but possibly a practise which most of them more or less follow, when the snow is in the right condition for doing so, has not been generally observed. The bird is not content to make its bed close to the door by which it has entered the snow, but generally bores a tunnel at the distance of a few inches under the surface to a distance of three or more feet, before it settles down for the night. The reason why the bird should go through so much apparently useless labour—for its night's bedroom would have been equally warm had it gone only a few inches beyond the door—was at first difficult of explanation, but a little more experience taught me to admire the intelligence of the

bird; for during my walks through the woods, I frequently came to places where a fox, lynx, marten, &c., had, in the night, approached cautiously (judging by the short footsteps), and made a spring at the hole where the snow had been entered. Had the bird remained near the entrance it would certainly have been killed, instead of which it had flown up a yard or more away and escaped uninjured. The prairie hens, a good many of which are to be found near Moose, show great intelligence in this respect, and in very cold weather even take their siestas during the interval between their breakfast and supper under the snow. I have often in the day-time seen them "pop" up their heads through the snow, without taking wing, before I got within gun range, no doubt to observe if it were an enemy that was approaching.

Without including the white grouse, peculiar to the Rocky Mountains, there are, I believe, three other kinds to be found in the northern parts of British North America. First, there is the willow grouse *Tetrao* (*Lagopus*) *saliceti* Sw. & R.—*albus* Aud., the most numerous of all, met with more or less abundantly at different seasons, at or near the arctic coast, on the barren lands and along the shores of Hudson's Bay, &c.

This bird, as I have already said, not only resembles the Scottish cock grouse in its summer plumage, with the exception of the wing-feathers being white in the former at all seasons, but in the pairing season their call and movements are so identical, that I consider them to be the same bird, modified to suit different winter climates.

The other recognized white grouse (*T. rupertris*) is so well marked by its smaller size, its more slender beak, its different call and the black patch or streak from the beak to the eye, that there can be no possibility of mistaking it for the other species. It bears a very close resemblance to the ptarmigan of Scotland. The third variety differs very considerably from both the above. Although about the same size as the willow bird, its beak appears shorter, its feet smaller, and its call perfectly different,

whilst its usual habitat, winter and summer, is chiefly on the islands (such as Wollaston and Victoria Lands) north of the Arctic coast. Here I saw a good many cock birds in the spring of 1851, but shot only a few, as they were very shy, possibly with the object of drawing me away from their wives, none of which were seen, as they were resting, and lay close on some of the lands uncovered by snow, where their already brown plumage was not readily seen. The cock retains its winter plumage to a much later date in spring than the hen does. These birds do not all migrate to the south to pass the winter.

All over the wooded portion of what is, or was, usually called the Hudson's Bay Company's Territory, east of the Rocky Mountains, comprising an extent of country equal to a quarter of Europe, the American hare (*Lepus Americanus*) is to be found in greater or less numbers; but it may not be generally known that these animals are every ten years attacked by an epidemic, so fatal, that from being in great numbers, they gradually die off until scarcely any are left, after which they begin to increase, and at the end of ten years are again at their maximum. I have myself, seen two cycles of this curious occurrence, and am acquainted with men in the Hudson's Bay Company's service who have witnessed four or five of these events. For instance, a friend wrote to me a few months ago, saying that 1884–85, were years of abundance, and 1880–81, years of scarcity, and that 1895–96 will again probably be years of plenty. My friend, the late Sir John Richardson, a distinguished naturalist and keen observer, states somewhere in "Fauna" "that the hares migrate." He must have relied upon erroneous information, and his residence in the country was at no one time long enough to enable him to observe for himself. After the epidemic commences, the hares are found dead in their forms, usually under small pine trees, the branches and thick brush of which grow close down to the ground. It is difficult to account, satisfactorily, for this regularly recurring and terrible epidemic, but it may be produced as follows: The hares are not spread broad-cast over the

country, but congregate at certain localities, say a mile or two in extent, where their favorite food of various kinds abounds. I believe these grounds after a time become poisoned by the excreta from the multitudes of hares, just as is the case with domestic poultry when kept too long on the same piece of land, or with grouse in Scotland, when allowed to increase too much. In winter when the grouse collect in great packs, and select as a shelter from westerly storms some favorite lee hill-side, I have seen the ground thickly covered with their "droppings," even in Orkney, where grouse have never, as far as I know, been numerous enough to be attacked with disease.

The effect of these epidemics is very peculiar and important, to the Indian, the fur trader and the fur-bearing animals in the far north-west. When the hares are numerous, the Indian pitches his tent at one of the locations I have named, and immediately cuts down a number of small pine and spruce trees as barriers, in which small gaps are cut for the hares in their "runs" to pass through. At the same time birch and other trees, the bark of which forms a favorite food of the hares, are felled, and on these they fatten rapidly.

Then many snares, perhaps a hundred or more, are set in the gaps mentioned, these snares are generally set and attended by the wife and children (if any), whilst the Indian himself constructs ranges of traps for the marten, fisher, lynx, &c., (which come to feed on the hares), extending for perhaps ten miles in two or three directions. These ranges are visited two or three times a week, the animals caught, taken out, and the traps re-set and freshly baited with meat or fish. In this manner the Indian passes a by no means laborious winter, his food being easily obtained, and the skins of the hares making excellent warm sleeping robes[1] and clothes for the children, and at the same time, he makes a good "*fur hunt.*"

[1] In making these fur-blankets, the hare-skins are cut up into strips, sewed together into a long line, which is roughly netted together, and although the fingers may be pushed through anywhere, it is one of the warmest robes known.

When the hares are scarce, the Indian has to go to a fishery to obtain a supply of food, or to travel about in search of deer or other large animals for food, whilst at the same time the fur-bearing carnivora, get scattered all over the country, also in search of food, and are not so readily trapped, and have thus an opportunity of increasing in numbers until the next season of abundant hares comes round.

There is a curious practise sometimes resorted to—not however common, as far as my observation extends—by the muskrats, to enable them to reach the food at all parts of the pond in which their house is built. In early winter, when the ice begins to form, the rats keep small holes open in different directions at a distance from their house, and build little huts of mud and weeds over these, into which they can enter and eat their food taken from the bottom of the pond, without having to swim all the way back to their house to do so. It has been only in large ponds or swamps that I have seen this done, and probably where there was an extra large number of rats in one house. On one occasion, when snowshoeing through a swampy part of the north-west, one of my men went very quietly up to one of these little shelters, and with a heavy blow of his axe knocked it over, and inside a poor little rat was found with some of the food it had been eating. It was knocked on the head, and in the evening formed part of the men's supper.

In 1851, in the early part of June, when on my way from the Arctic Sea, where I had been making a long sledge journey of more than 1000 miles, I was surprised to meet thousands of lemmings travelling with all the speed in their power to the north. On some of the tributaries of the Coppermine River the ice had broken up, and at these it was curious to see these little animals running up or down the southern bank of the stream looking for a smooth place with little current at which to swim across, having found which, they immediately jumped in, swam with great rapidity, and gave themselves a shake, as a dog would do, when they reached the opposite side, and then

continued their advance as before. This was in latitude between 67° and 69° north; so the sun was visible all the twenty-four hours, and we travelled at night so as to have his light on our backs. Had we been travelling in the day time, we would not have seen one of our little friends, as they then hide themselves under the snow or stones. Having accidentally lost the small quantity of food we had with us, by the man carrying it falling when fording a rapid, our chief food for two or three days was these lemmings, which we found very good when roasted between two thin slabs of limestone, heated by andromeda as fuel. Our three dogs also picked up as many as they required. It is well known that the lemmings of Norway and Sweden frequently migrate in immense numbers, but I did not think that those of America did so. They are found very far north, as they were abundant where the Nares Expedition wintered, in latitude 82° north, up Smith's sound. Here, as elsewhere, they formed a considerable portion of the food of the white fox.

That beautiful animal, the arctic hare, has a rather artful dodge which it resorts to, evidently with the object of throwing his enemies off the scent. After feeding at night in the lower grounds, it generally resorts to some higher position to lie hid during the day, and the sportsman in following his or her track, is surprised to come to a place where there are several tracks one over another, causing confusion. On going further, he comes to the end of the track altogether, the animal having jumped off somewhere; and on retracing his steps, carefully inspecting both sides, two little marks are seen in the snow at a distance of twenty feet or more from the track, always on the *lee side*, so that a fox or wolf could not catch the scent. These long jumps are repeated three or four times,—the animal evidently either using only his hind legs, or putting all his four feet close together. Experience soon taught me that the hare was in his form at no great distance from these "jumping off" places, and a sharp look-out had to be kept, as if you happened to walk directly for him he

would usually slip away under shelter of the large stone or rock near which he lay. When noticed, the sportsman should walk as if apparently passing by the hare, taking care not to look directly at him, but at the same time approaching, and when near enough, wheel round and fire; for you must do with the hare as with the ptarmigan among the rocky hills of Scotland— take him *any way*; otherwise he is in a moment round the corner and safe.

These hares seem to have puzzled the officers and crew of McClure's ship in the Arctic, when he wintered in Prince of Wales sound. They were so numerous as to be seen in droves of hundreds at a time, yet only seven were killed in a month by the sportsmen, in a crew of about sixty persons. On a somewhat similar occasion, but with fewer hares, I shot ten in little more than an hour, and carried them to our snow hut, their average weight being about 8 lbs. each.

Whilst walking one day in August along the shore of Victoria Land, latitude 69° north, the tide ebbing, I heard a clattering among the small limestone debris on the beach, which reminded me of a sound very common and often heard many years before in winter, on the shores of the Orkney Islands. On cautiously looking over the bank, there, sure enough, I noticed a family of turnstones (*Tringa interpres*), two old and three young, busy turning over stones and feeding on the insects underneath. They looked so happy and were so fearless, that I had not the heart to shoot any of them for specimens.

The American golden plover, commonly called the "*ox-eye*," must breed in immense numbers, at least as far north as 70° to 71°, as I saw large flocks of them flying to the south towards the end of August, when on the south-east corner of Victoria Land, on the shore of Victoria strait, in 1851. Great numbers of snow geese were at the same time noticed making their way apparently to Back's Great Fish River, and thence probably to Great Slave and Athabasca Lakes. The Coppermine River is also one of the lines of flight of these birds, both in going to and returning from their breeding places. They were very abundant in the autumn

of 1848, and in the spring of 1851, near the mouth of the Coppermine River when I was there, and not being difficult of approach, I shot a good many. Those killed in the spring were very fat.

Perhaps I may mention that it is, especially to the sportsman or naturalist, a very pretty sight to see the snow and blue-winged goose (wavy) arrive at the marshes of James' Bay, after their long flight from their breeding place. A strong breeze of northerly wind usually accompanies their advent, and their call is generally heard before they are seen, high up in the air, going at express railway speed. Suddenly several of the leaders of the flock, no doubt old birds, make a dive downwards, apparently in the most frantic and reckless manner, followed by others in a more or less adroit manner, making a great cackling all the time, until the whole have got pretty low down, when having fixed upon a resting place, they wheel, round head to wind, and alight on the marsh. Flock follows flock, all going through similar manœuvres, each new arrival being received with noisy and hearty congratulations of welcome by their predecessors.

It may not be out of place to notice, that I do not think any snow or blue-winged geese breed on any part of the shores of Arctic America proper lying west of Hudson's Bay and east of the McKenzie, unless it be in some large marshes near the mouth of that great river on the Melville Peninsula, whereas most of, if not all, the blue-winged "wavies" breed on lands and islands east of Hudson's Bay.

On Sporocarps Discovered by Prof. E. Orton in the Erian Shale of Columbus, Ohio.

By Sir J. Wm. Dawson, F.R.S., &c.

In a paper published in this journal in 1884, I directed attention to certain specimens from Brazil and from Ohio, which I placed in connection with the curious round bodies from the Erian or Devonian of Kettle Point, Lake Huron, discovered by Sir W. E. Logan, and which I described as *Sporangites Huronensis.* These bodies were shown to be macrospores, and, on the analogy of the Brazilian species, to have been probably enclosed in sporocarps resembling those of the modern genus of Rhizocarps known as Salvinia, and found floating in water, with a few green leaves and rounded sporocarps on the bases of the leaves or at the proximal ends of the roots. These curious little plants, insignificant in the modern world, would seem to have been vastly abundant in the Erian period, inasmuch as hundreds of feet of the Ohio black shale are filled with them; and this formation extends across the State of Ohio, and is found in New York and in Ontario as well. But though the macrospores are thus abundant, the sporocarps, which it was presumed had contained them, were absent. Quite recently, however, Prof. Orton has found at Columbus, Ohio,[1] well-preserved sporocarps flattened like those from Brazil, exhibiting their cellular structure quite distinctly under the microscope, and sometimes showing the impressions of the contained macrospores. Along with these sporocarps were others of quite different form, and apparently belonging to a very distinct species, though probably of the same general type—that is, allied or belonging to the Rhizocarps. Prof. Orton has kindly furnished me with specimens of these curious bodies, and the following notes relate to their characters. What should now be looked for is some indication of the foliage of these interesting plants, which may prove to have been like that of the modern Sal-

[1] The specimens were collected by Mr. C. J. Walsh.

vinia, or perhaps somewhat more advanced in complexity of structure, as these old forms of vegetation usually present types of structure in advance of those of their modern successors in the same groups.

The specimens occur plentifully on the surfaces of a firm dark gray shale. They are perfectly flattened and carbonised, and so loosely attached that they can readily be removed, as thin pellicles, which when partially broken, often show their double walls. As opaque objects, under a low power they present a shining surface marked with cellular areolation. In this they resemble the Sporocarps of *Protosalvinia Braziliensis.*[1] When removed from the matrix, and immersed in water or in Canadian balsam, they become transparent, and show their thick-walled cellular structure very distinctly. The transparency is somewhat increased by boiling for a short time in nitric acid.

There are two distinct forms on the surfaces of the shale —one, which is the more common, perfectly circular; the other, elongate obovate, and notched at the apex, sometimes so much as to give a bifurcate appearance.

1.—*Sporocarps of Protosalvinia Huronensis.*

These are the circular specimens. I refer them to this species, because its macrospores are the most common fossils of this shale, because they resemble those of *P. Braziliensis,* and because some of the specimens show impressions of contained macrospores similar in size to those of the species *Huronensis.*

They are rather larger than the sporocarps of *P. Braziliensis,* some being four millimetres in diameter. They are, therefore, considerably larger than the sporocarps of the modern *Salvinia* of Europe. In structure they are coarsely cellular, more thick-walled and larger-celled than those of *P. Braziliensis,* probably indicating a good specific difference. Both of these ancient sporocarps are composed of coarser cells and more dense in texture than those of

[1] Record of Science, 1884.

Salvinia natans, though indicating a plant of similar general type. I have stated in my previous paper the probability that such sporocarps would be found, and their discovery is therefore very satisfactory.

2.—*Sporocarpon furcatum.*

The smaller and probably immature specimens of this organism are obovate and broadly truncate below, with a slight emargination at the apex. Larger and probably mature specimens have a very deep slit at the apex, or divide so as to give a bifurcate appearance. Length of one of the larger specimens, 5.5 millimeters; breadth, near the apex, 2 m.m.; at base, 1 m.m. Surface with fine cellular reticulation, which, when seen as a transparent object, appears as a network of thick-walled cells, rather finer than that in the previous species, but of the same general character. Toward the base. it becomes more lax, as if verging into an ordinary epidermal tissue. No contained spores or macrospores were observed; but it can be seen that the specimens are not mere fronds, but have a double wall and are really flattened sacs.

FIG. 1. SPOROCARPON FURCATUM.

(*a*) Natural size. (*b*) Young specimen (mag.). (*c*) Full grown specimen (mag.), showing cellular areolation. (*d*) Cellular structure, highly magnified.

These objects are, therefore, to be regarded as sporocarps or spore-cases of some unknown plant, saccate in form, and

dividing at the distal end into two sacculi, the dehiscence of which seems to have been by a slit on the inner side of each division. This last property and their form recall the spore-cases of the ferns of the genus *Archaeopteris*, which are, however, different in other respects. They still more nearly resemble the spore-cases of Psilophyton (see figures in my Report on the Erian Flora of Canada, 1871), but the latter are entirely separate and supported upon slender stalks. Some tendency to the double or divided form of these Sporocarps, though much less pronounced, occurs in the *Protosalvinia bilobata* from Brazil.[1]

I should suppose that these bodies belonged to a genus distinct from Protosalvinia, but ordinally related to it. The form of the base would seem to imply that they grew on a frondose or thick pedicel. Possibly they may have been attached to the sides or bases of fronds; but this must for the present remain uncertain.

Williamson has used the generic name *Sporocarpon* for conceptacles of various forms and structures from the carboniferous, of which he remarks that he has formed no opinion of their relations, but which may have been Rhizocarpean, inasmuch as the nearest modern analogues of some of them appear to be the sporocarps of Pilularia. For this reason I have thought it best to place the present species in this provisional genus, till farther information can be obtained as to the nature of the other organs of the plant to which they belonged. It would now be a very desirable discovery to find the vegetative organs of these ancient plants. For other facts bearing on the affinities of these organisms, I would refer to the papers above cited, and to my little work, "The Geological History of Plants."[2]

[1] Record of Science, 1884. Bulletin Chicago Academy, 1886.
[2] Appletons, New York, 1888.

Note on Graptolites from Dease River, B.C.

By Prof. Charles Lapworth, F.R.S.

In June, 1887, a small collection of Graptolites was obtained by Dr. G. M. Dawson on Dease River, in the extreme northern and inland portion of British Columbia, about lat. 59° 45′, long. 129°. These fossils were derived from certain dark-coloured, carbonaceous and often calcareous shales, which, in association with quartzites and other rocks, characterize a considerable area on the lower part of the Dease, as well as on the Liard River, above the confluence. The collection referred to was transmitted by Mr. J. F. Whiteaves to Prof. Lapworth, whose special studies on Graptolites are well known. It is believed that the following preliminary note by Prof. Lapworth will be of interest, as the occurrence of Graptolites on the Dease River extends very far to the north-westward of our previous knowledge of the occurrence of these forms in North America. In 1886 a similar small collection was obtained by Mr. R. G. McConnell near the line of the Canadian Pacific Railway, in the Kicking Horse (Wapta) Pass. This and the new locality here described are the only ones which have yet been found to yield Graptolites in the entire western portion of the Dominion.

Prof. Lapworth, under date December 13th, writes as follows:—

I have, to-day, gone over the specimens of Graptolites, collected by Dr. Dawson, from the rocks of the Dease River, British Columbia. I find that they are identical with those examined by me from the rocks of the Kicking Horse Pass, some time last year. The species I notice in the Dease River collection are:

Diplograptus euglyphus, Lapworth.
Climacograptus comp: *antiquus*, Lapworth.
Cryptograptus tricornis, Carruthers.
Glossograptus ciliatus, Emmons.
Didymograptus comp: *sagittarius*, Hall.
New form, allied to Cœnograptus.

These graptolite-bearing rocks are clearly of about Middle Ordovician age. They contain forms I would refer to the second or Black River Trenton period: i.e. they are newer than the Point Lévis series, and older than the Hudson and Utica groups. The association of forms is such as we find in Britain and Western Europe, in the passage beds between the Llandeilo and Caradoc Limestones. The rocks in Canada and New York, with which these Dease River beds may be best compared, are the Marsouin beds of the St. Lawrence Valley, and the Norman's Kill beds of New York. The Dease River beds may perhaps be a little older than these.

Mr. C. White described some Graptolites from beds in the mountain region of the West, several years ago, which may belong to the same horizon as the Dease River zones, though they have a somewhat more recent aspect.

The specific identification of the Dease River fossils, I regard as provisional. While the species correspond broadly with those found in their eastern equivalents, they have certain peculiarities which may, after further study, or on the discovery of better and more perfect specimens, lead to their separation as distinct species or varieties.

It is exceedingly interesting to find Graptolites in a region so far removed from the Atlantic basin, and also to note that the typical association of Llandeilo–Bala genera and species is still retained practically unmodified.

THE GREAT LAKE BASINS OF CANADA.

BY A. T. DRUMMOND.

In a paper read recently before the Royal Society of Canada, on "The Origin of Some Geographical Features in Canada," Dr. Bell alluded more particularly to the lake region of the Dominion, including in this not only what is

NOTE.—This preliminary note comprises a short extract from the closing lecture in Science, delivered by the author before the authorities of Queen's University on April 23rd of this year, and its publication has been suggested by Dr. Bell's more recent paper, above alluded to, read before the Royal Society.

popularly known as the Great Lakes, but also those vast stretches of water which form the sources or expansions of the Mackenzie, Churchill and other rivers which fall into the Arctic Sea or Hudson Bay. Lake Superior was alluded to as being in part of volcanic origin, whilst the vast basin of Hudson Bay was referred to as being in some respects due to similar causes. On the other hand, Lake Athabasca, Great Slave Lake, Lake Winnipeg, the Georgian Bay and Lake Ontario lie more or less along the line where the limestones and sandstones meet the older Laurentian and Huronian strata, and he attributed their excavation to the action in post-tertiary times of glaciers, which, descending from the then greater elevations to the northward, had in their southern course torn away, one after another, the upturned edges of these softer limestones and sandstones. This process going on for ages, resulted in the formation of these lake basins.

Dr. Bell also pointed out that dykes of greenstone, &c., often formed the original lines along which the channels of rivers, arms of lakes, and fiords were by denuding forces cut.

The whole subject still merits careful investigation. Dr. Bell's opinion that the Great Lake basins have a glacial origin, is the commonly received impression among scientists. Too much importance has, however, been attached to the influence of glaciers. It has been recently shown by Prof. J. W. Spencer that they have much less eroding power than has been attributed to them. If we draw reasonable conclusions, especially from correlated physical conditions as they now exist, serious difficulties present themselves in the way of accepting the theory, still adhered to by American geologists, of a vast, continuous, continental glacier covering the Arctic and northern temperate regions of North America, and with its enormous tongues of ice forking into Massachusetts, New York, Indiana, Illinois, Iowa and Wisconsin. Equally are there difficulties in the way of accepting the great thickness of the ice-sheet, which some, judging from the crushing power of a column of ice,

have estimated in places at several miles. Scientists have apparently somewhat overlooked the vast effects of erosion by atmospheric and other agencies in Miocene and Pliocene ages which immediately preceded the glacial epoch, and the great deposits of decomposed rock which must have accumulated during these ages in northern temperate America. Nor have they fully considered the immense elevation, if even by accumulated ice, necessary in our Laurentian area and southwestward, to admit of great glaciers finding their way in a massive stream for, as in the Lake Michigan glacier, four hundred and more miles from the Laurentian or Huronian mountains, and, generally, in a direction which is presently up instead of down the natural incline of the St. Lawrence valley and Great Lake basins. For a glacier from the Laurentian mountains to have reached even the head of Lake Michigan would, at the rate of progress of the enormous Humboldt glacier in Greenland, as measured by Dr. Hayes, have taken about 21,000 years; and whilst the climates are, for argument, assumed to have been similar, the Greenland slope is greater than that through Lake Michigan could possibly have been.

If, again, the Great Lake basins had been each overspread by a vast moving glacier, there is a strong probability that during the onward progress and the subsequent slow recession of the ice, the inequalities of the lake bottoms must have been worn away or largely filled up with the debris which continually accompanied the glaciers. Nevertheless, Lake Michigan has a depth varying from 700 to 1800 feet, and, excepting Lakes Erie and St. Clair, the other lakes have equally varying depths.

It has, also, not been considered that continental glaciers even only one mile in thickness, extending over the Arctic and northern temperate regions of Europe, Asia and America, would represent a depth of about 500 to 600 feet taken uniformly everywhere from the waters of the ocean and transformed into ice, even supposing that a milder climate existed at the Antartic Pole. Apart from the effects on the general level of the continents which the weight of

these enormous masses of ice would have, and of the heat generated underneath which would probably prevent any excessive accumulation, the withdrawal of a depth of 600 feet of water from the North Atlantic Ocean would have moved the whole United States coast line from Texas to Maine about seventy-five to one hundred miles seaward of its present position, would have rendered the Gulf of St. Lawrence dry land, and brought to the surface the Great Banks of Newfoundland, would have obliterated the German Ocean, thus connecting Great Britain with the continent of Europe, and would have almost formed an isthmus between Great Britain and Iceland. How far are we prepared to accept these results as occurring simultaneously at this time? Some of them actually did occur at other periods, but through the slow elevation of the land.

The subject of the origin of the Great Lakes is still beset with some difficulties. Whitney, and more recently R. D. Irving, have shown that Lake Superior throughout its whole area is a synclinal trough or depression, and that the Keweenaw series of rocks in its upper and lower divisions probably underlies nearly the whole lake. This, then, largely dispels the idea of the glacial origin of this lake. When this depression took place is a more difficult question. Through its western half the axis of the depression lies in a southwesterly direction and, in a general sense, parallel to the trap overflows of the western shore, showing that they may both be due to the same force.

Again, Lakes Erie and St. Clair, which without doubt have at one time been united more intimately than now, are probably the most recent in origin of the Great Lakes. The county of Essex, which now separates them, has quite the characteristics of the modern prairie, and its formation is undoubtedly due to similar causes. Centuries of growth and decay of rich grasses and sedges in the extensive marshes here bordering the lake, gradually contributed a loamy soil, which even now is not much above the level of Lake St. Clair. These two lakes lie in very shallow depressions in the Erie clays—Lake Erie in its southwestern half

having a maximum depth of about seventy feet, whilst Lake St. Clair has a maximum depth of only twelve feet. These lakes appear rather to be shallow overflows caused by the restricted passage now of the waters over the Niagara escarpment in the one case, and through the Detroit River in the other, than to be due to physical forces which, operating in past ages, excavated preparatory basins for them. There can be no doubt that, as Dr. Hunt suggests, the post-tertiary clays of south-western Ontario now occupy the basin of what may have in earlier times been a much larger lake or inland sea.

Regarding the operation generally of glacial forces in contributing in some respects to the features of our Great Lakes, we can conclude that our whole Laurentian and Huronian country north of these lakes and of the St. Lawrence was elevated into great mountain chains, that, with the colder climate, enormous glaciers everywhere flowed down the mountain sides and over the country beyond, and that contemporaneously, probably towards the close of the age, there were, as has been shown by Sir William Dawson, extensive depressions in the eastern parts of Canada, and of the northern United States, which admitted tha Arctic current laden with huge icebergs up the St. Lawrence and across the basin of the Great Lakes; or, what is more probable, that the Great Lakes formed an inland sea which extended over parts of the Northern States as well. Across this inland sea and towards the Mississippi River, which was probably then its outlet, floated numberless icebergs, the offshoots of the Laurentian glaciers to the northward, freighted with their loads of boulders and debris, which were dropped on the sea bottom as the bergs melted, or were broken by contact with other bergs or with rocks. Our North-West, as far as the Rocky Mountains, was at this time, or subsequently, the floor of an even vaster sea, with the prevailing winds or currents carrying, in the direction of these mountains, fleets of icebergs from the great glaciers on the eastern borders of the sea, which were then on a line with the present Lake

Winnipeg. Further, whilst during a part of this colder period, there was a high northern temperate vegetation, including in it such trees as the balsam poplar, the white cedar, and the mountain maple, there is some evidence in the North-West that since the close of tertiary times there have been two separate periods of cold, intermediate between which was a milder period when a vegetation on a considerable scale flourished. During perhaps each of these periods of cold the central parts of the continent formed a great inland, probably fresh water, sea, of the later of which the present Lakes Manitoba, Winnipegosis and Winnipeg are the remnants.

PROCEEDINGS OF ROYAL SOCIETY OF CANADA.[1]

With Notes by A. T. DRUMMOND.

Under the presidency of Dr. Lawson, of Dalhousie College, Halifax, the Royal Society of Canada commenced on the 21st May the sessions of its annual meeting at Ottawa. There was a smaller attendance of members than could have been desired. The great length of the journey to Ottawa must no doubt deter some members from being annually present, and unforeseen reasons must occasionally prevent others; but the absence of so many members is apt to be construed into a lack of appreciation by them of the Society's work, and is, besides, discouraging to those who have interesting papers to read. It was thought by some that a change in the date of the annual meeting might secure a better attendance.

PRESIDENT'S ADDRESS.

The annual address of the President was listened to, as usual, with great interest The following extracts give the leading features of Dr. Lawson's address :—

[1] Abstracts marked with an asterisk have for the most part been specially prepared for the Record by the authors of the papers.

"My first duty on this occasion is to express to you, fellow members, my personal acknowledgment and thanks for the honour you have bestowed in placing me in the high position of President of the Royal Society of Canada, an office whose character is sufficiently shown by the mere mention of the names of those whom you selected to fill it in former years—Sir William Dawson, Dr. Chauveau, Dr. Sterry Hunt, Dr. Daniel Wilson, Monsignor Hamel. It would be difficult to select five other living names more intimately associated than those with the intellectual, educational and industrial developement of Canada, or engraven in clearer lines in the records of our literature and science, or more deeply impressed upon the hearts of those classes of our people who are thoughtful, intelligent and enterprising. I might well then shrink from taking this chair and attempting to discharge the duties that pertain to it. If I had thought that your selection had been made solely on the ground of personal fitness, or as an acknowledgment of work done or to be done in any individual capacity, I should have hesitated to assent to your choice, or to attempt the task which acceptance involved. But the considerations which led to my acquiescence were of a different kind. I felt that we were working together for the success of this society, not as an end in itself, but as a means—an organization—whereby we might be enabled, in some measure, to contribute our part in accomplishing the country's good, promote literary and scientific research and discovery, educational improvement, industrial development and general intellectual activity throughout this Dominion; that we were charged with this work, and each bound not to shrink from the part that might be allotted to him; that we were here, moreover, as members not only in our individual capacities, for what we might do with our own hands, but also as the representatives of other active labourers in the several departments of knowledge scattered through the various provinces; that once a year we might one and all come to the common meeting place, not merely to give account of the results reached by our personal

efforts, in the way of trying to push forward the boundaries of the known or to clear the way for discoveries by others, but that we were also expected to bring in our hands the offerings of co-workers with whom we were more or less closely associated in our respective districts. For these reasons I was led to regard your choice of a president from the extreme eastern part of our long and wide country as a choice deliberately made in pursuance of a wise and safe policy, often referred to in our deliberations, that aims not only at recognizing every department of literature and science, and every form of intellectual activity, but also as offering, to the fullest possible extent, fair representation and encouragement to every province and every part of the Dominion. I trust that this policy, and the principle upon which it is based, will long continue to guide the deliberations of the members and council of this society in the selection of officers, so far as compatible with efficiency, and of its several sections, in the nomination of members.

"These remarks naturally suggest a fact of another kind, viz., that a large amount of the executive business during the year, when the Society is not in session, and when it is inconvenient for distant members of council to attend, has necessarily to be performed by a small number of those who reside within convenient distances of Ottawa or Montreal. Responsibilities and labour thus devolve upon the few that should otherwise be spread over the many. This is especially the case in regard to the publication of transactions, which involves a serious amount of irksome labour. If we, the distant members, cannot lighten it any, it may be permissible to say that while not insensible of the unavoidable disadvantages under which we labour, and which often limit our participation in the Society's operations in many ways, we yet have but one feeling in regard to the laborious and thoroughly efficient manner in which, through many difficulties, the work of publication has been carried on. We are grateful for this to our active members in Montreal and Ottawa, whose labours are apt to be overlooked, and especially to our active secretary, who is styled

honorary, on the sound principle, I presume, that the greater the labour the greater the honour. We have also the comfortable assurance, expressed in many tangible ways and not as a mere sentiment, that by seeking to maintain the activity of the distant provinces, the Society will have the surest guarantee against the tendency to centralization, which seemed to some of us from the first to menace it, and the best prospect of success in carrying out its aim of permanent usefulness to the whole Dominion.

"We first assembled as a society in the railway committee room in the parliament buildings on the 25th of May, 1882, and have come together annually since then, so that we are now engaged in our seventh year's work. The record of the preceding six years is contained in our five volumes of proceedings and transactions, a perusal of which enables us to ascertain to what extent the objects set before us are being accomplished.

"But from the very nature of our organization, being divided off into sections for facilitating work, and meeting in separate rooms, we are apt, as working members ourselves, to be but imperfectly cognizant of the full extent of what is actually being accomplished by the Society as a whole. If it be so among ourselves, how much more is a paucity or total absence of knowledge of what we are doing likely to prevail among those who are merely onlookers. When we are here assembled together, the members of all sections, and favoured by the presence of friends who manifest an interest in our proceedings, I do not know that the hour can be spent more profitably than by adverting to some of the work of the past year, completed by the publication of the fifth volume of transactions, now ready for distribution."

Dr. Lawson then adverted in detail to the several subjects upon which the members had contributed papers during the year, and, first, to the great importance of a system of observations of tides and currents in the waters of the Dominion, in regard to which the Society had been co-operating with the British Association for the Advancement of Science, with

the view of pressing the matter upon the attention of the Home and Dominion Governments. The report on a scientific federation of the Empire had been discussed in correspondence between Sir William Dawson and Prof. Stokes, President of the Royal Society of London, and the matter of the International Geological Congress had been referred to Section IV. During the past year, forty-five memoirs had been published by the Society, out of about seventy read. In his address last year he had called attention to the preponderance—not unlooked for—of papers in the fourth section over those especially in the sections of French and of English literature. In the new volume, this discrepancy well nigh disappears, and in the programme for the present year there is a further increase in the literary sections, so that, apparently, the contributions of English literature have doubled, and of French trebled, in the course of two years. On the other hand, the difficulty of reaching perfection in literary production, where we are dealing with progressive science, was illustrated by the fact that of forty papers submitted and read last year in the section for geology and biology only twenty-one reached the printer's hands. The first section, French literature and history, was referred to as the special repository for choice literature and for researches in the very earliest Canadian history, the beginnings of European life in Canada. The Abbé Casgrain's elaborate memoir on the Acadians was specially dwelt upon as a valuable contribution to a striking episode that had been so invested with poetic imagery that the scalpel of science was needed to lay the truth bare. No more fitting company than the members of this Society could undertake the work, formed as they are of compatriots representing the two races, using the two languages, and bound together by a singleness of purpose to seek the truth. In the second section, English literature and history, the several contributions of Mr. Lesperance, Mr. Ganong, Sir Adams Archibald, Mr. Reade, Dr. Boas, Mr. Lucien Turner and Dr. George Dawson were spoken of in turn, and their special bearings indicated, either as regards results obtained or as aids in the

promotion of research. In the third section, mathematical, physical and chemical sciences, Mr. Macfarlane's address was specially spoken of as indicating the industrial results of chemistry; Mr. Hoffman's analyses of native Canadian platinum; the contributions of Mr. McGill and Dr. Ellis to analytical processes; Dr. Ruttan's paper on digestibility of bread as affected by baking powders and alum; Dr. Harrington's observations on the flow of sap in the western maple; Mr. Coleman on microscopic petrography, and Mr. Bovey's investigation in regard to girders. In the fourth section, geology and biology, the Abbé Laflamme gives a valuable contribution to the history of science and medicine in Canada, in a biographical study of Dr. Michael Sarrazin, whose name was linked by the renowned early French botanist, Tournefort, to our pitcher plant, Sarracenia. Prof. Penhallow's review of Canadian botany from the first settlement of New France to the eighteenth century was fully referred to in special relation to the early connection of the history of botany in Canada and in Europe; Dierville having carried Acadian plants to Tournefort, and Peter Kalm, of Abo, in Sweden, having, through encouragement of Linné, spent four years in Lower Canada collecting plants, which he cultivated afterwards in his garden, whilst Menzies, the Scotch botanist who accompanied Vancouver, collected on our Northwest coasts and around the Halifax harbour before the close of the last century. Dr. C. Hart Merriam answers in the affirmative, for the hoary bat, the question, Do any Canadian bats migrate? Messrs. Hay, of St. John, and A. H. Mackay, of Pictou, give a list of the marine algæ of the Maritime Provinces, which will necessarily be useful to students, to whom these plants present an inviting aspect as an illimitable field for study of life histories.

Dr. T. Wesley Mills, in his able paper on the mental endowments of squirrels, brings these creatures forward in a new light. Prof. Fowler tabulates the Arctic plants of New Brunswick, and Mr. Payne gives his observations made on the periodical phenomena of vegetation throughout the season at Cape Prince of Wales, Hudson Strait. In

geology we have Mr. Gilpin's accounts of the faults and foldings of the coal-field of Pictou, Nova Scotia; Sir Wm. Dawson's valuable addition to what he has already done in regard to our fossil flora; Prof. Bailey's notes on the physiography and geology of Aroostook, Me., in connection with regions of New Brunswick and Quebec, etc. Mr. McKellar communicates a paper on the corelation of the Animikie and Huronian rocks of Lake Superior; Dr. Franz Boas, on the geography and geology of Baffin Land, with interesting observations on ice action. Mr. Lucien Turner describes the physical and geological character of the Ungava district of Labrador, fully three-fourths of which is bare rock, mainly Laurentian, showing disintegration of the higher altitudes, while the lower and older rocks are smoothly polished by glacial action; the climate is severe, the vegetation dwarfed. Prof. Spencer, formerly of King's College, Windsor, communicates two papers on Glacial Erosion in Norway, and the theory of Glacial Motion. In the first he describes from personal observation the three largest snowfields in Norway (one of which has an area of 580 square miles), all of which send down glaciers to within 50 to 1200 feet of the sea; in the second, he adopts the old (J. D. Forbes) theory of fluidity as the most acceptable explanation of the motion of glaciers. The petroleum field of Ontario, its history, theory of origin, and the operations carried on, are all described by Dr. Bell, the president of the section. Mr. Matthew, of St. John, continues his illustrations of the fauna of the St. John group, and describes the remarkable trilobite, found by himself, apparently the largest hitherto discovered, which he appropriately honours with the title—*Paradoxides Regina.*

The President then remarked: "At the double risk of proving tedious to hearers and unsatisfactory to authors, I have given this sample of a year's work to indicate the nature and extent of the researches in which our members are engaged. Referring to the uses of scientific periodicals and societies devoted to special branches, or with local objects, it was a main object of the Royal Society to foster

these, and encourage the publication by them of matter of immediate and local interest, whilst its own transactions would form a repository for finished memoirs of as complete a character as the state of knowledge will permit, and adequately illustrated, for permanent use, and not merely designed to furnish information on their special subjects, but also to form foundations and guides for further research. Hitherto, information in regard to any question in Canadian history, literature or science, had to be looked for through the scattered papers in periodicals, and proceedings of societies published in many countries and in different languages. Our transactions are now a storehouse for everything that may be judged of permanent value in relation to science and literature in Canada. We may hope that year by year the publication will increase in volume and in cumulative value, and that the student seeking for the latest information on any subject may be able to turn to it with some confidence that his needs will be supplied."

The contributions to literature and science presented to the Society during the present meeting were numerous, and not inferior in character to those of other meetings.

Among the interesting papers in the literary sections were those on the Indian tribes of British Columbia and their languages. The Rev. A. J. Hall submitted a grammar of the Kwakiool people of Vancouver Island, whilst Dr. Franz Boas presented two papers—one on the Indian tribes of British Columbia and the other on the Nanaimo Indians. The higher civilization of many of these west coast Indians, and the very mountainous character of much of British Columbia, preventing the rapid inroads of the white man, may possibly even lead to an increase in the numbers of the tribes there. Thus these investigations may have more than an ethnological value. The whole subject of the North-Western tribes has engaged the attention of a committee of the British Association for the Advancement of Science, and recently a circular of inquiry has been issued

with a view of eliciting information from those who have in past years had, or now have upon the spot, the opportunity of observing the differences in language, the social customs, and the mental and physical characteristics of the different tribes of Indians. Education has now been tried for some years in a few localities. What success has attended the effort? Has there been any proof or disproof of the received impression that the children of the Indians show, up to a certain point, a fair capacity for mental work, but that at this point the intellectual development appears to cease? If this impression is correct, has the cause been studied? Many such interesting fields of inquiry are suggested by the circular.

Among the papers in geology and biology were the following:—

*On the Nymphæaceæ.**

BY GEORGE LAWSON, Ph.D., LL.D.

"An account was given of the general conformation and of the arrangement of tissue systems in the organs of these plants, and of special features in their organization and minute anatomy. The South American Water Lily, *Victoria Regia*, had been, years ago, carefully studied by Planchon, whose researches were published in Flores des Serres, Vol. VI., p. 249, &c., and by Trecul, who illustrated the more important facts of its structure, and the development of organs, in the Annals des Sciences Naturelles, Botanique, 4 ser., I., pp. 145-172. Some facts well known a quarter of a century ago seem to be forgotten now. Lately, De Bary, in the Comparative Anatomy of Phanerogams and Ferns, and J. H. Blake, of Cambridge, in the new Annals of Botany (August, 1887), question the explanations given of the structure of the prickles of the *Victoria*, and especially the character of the ostiole or depression at its apex. The author of the present paper had shown, as long ago as 1855, the true character of these prickles, and that the ostiole had no special function, as had been argued (and in-

ferentially was not pathological as now suggested by Blake), but 'a simple depression in the apex of the prickle of no physiological importance.' (Proceedings Bot. Soc. Edin., November, 1855, on the structure of *Victoria Regia*, Lindl. By George Lawson.) In the same paper it was shown that the stomatodes or perforations of the leaf were not mere holes, caused by insects, as argued by Trecul, and accepted on his statement by Blake, but special structures of uniform size, formed by surrounding modified cells, and comparable with the more complete reductions of parenchymatous tissue seen in submerged plants and in *Ouvirandra fenestralis*; moreover their special function in *Victoria* was indicated.

"A statement is given of the historical facts connected with the nomenclature of the Nymphæaceæ, with regard to the proposal recently made by some American and English botanists to give up the generic name *Nymphæa* to the group now well known as *Nuphar*, and to re-instate Salisbury's name *Castalia* for the true Water Lilies. The paper also contains a synopsis of species.

"A series of coloured drawings illustrated the minute structure of the *Victoria*. These were made from a plant that flowered in the autumn of 1851, in the nursery of Knight & Perry, King's Road, London, and another grown in the Botanic Garden, Glasgow, in 1855. They show the epidermis and stomata—the latter with chlorophyll granules—of the upper surface of the leaf; the surface cells, hairs, and base hairs, of the lower surface; the prickles, in several aspects and sections, showing internal tissue, ostiole, &c.; the air spaces of the leaves, with the large stellate processes projecting into them sculptured with bead-like markings as in diatoms; colour-cells of the lower surface; stomatodes, or perforations, surrounded by oblong cells filled with deep rose-coloured contents; surface petal-cells, with crimped cell-walls and filled with rosy colouring matter, of varying depth of shade."

*Revision of the Canadian Equiseta.**

By George Lawson, Ph.D., LL.D.

"The genus *Equisetum*, Tournefort, is composed of a comparatively small number of existing species. They are plants with subterranean or submerged rhizomes, sending up hollow, jointed stems, which are either simple (unbranched) or bear verticils of branches at the joints, similar to the stems, but smaller in size. Both stem and branches are longitudinally grooved, and punctated with lines of stomata along the grooves. These plants are leafless, the foliar organs being reduced and cohering into tubular sheaths at the joints, with the leaf-points only free as teeth. The cuticle is more or less highly silicified, so that in some species the plant retains its form after its vegetable matter has been removed. The genus constitutes a natural order by itself, well defined both by structural characters of the vegetable organization and peculiarities in the reproductive organs. Even regarded as an order, these plants are isolated, cut off from near relationship with other groups. This fact, taken in connection with the differences of minute structure and modes of growth observable among the existing forms, and their wide geographical distribution, indicates that they may be a remnant of what was formerly a more multitudinous group of species and varieties. Linnæus (who is not the author of the genus, although always so credited) gave, in the Species Plantarum, seven species, of which only one (*E. giganteum*) was then (1764) known to exist in America. Alex. Braun, of Carlsruhe, prepared a Monograph of the North American species, which was translated from the author's MS by the late Dr. George Engelmann, of St. Louis, and, with some additions, published in the American Journal of Science for October-December, 1843 (vol XLVI., No. 1, pp. 81–91). A synopsis of the Canadian species was published by the writer in the Edinburgh Botanical Society's Transactions, in 1863 (vol. VII., pp. 558–564), and subsequent additions were made, in the Synopsis of Canadian Ferns and Filicoid Plants, in 1864 (Trans. Bot. Soc., Ed., VIII., pp. 20–50,

and Canadian Naturalist, 1864). In 1866, Dr. J. Milde, a most painstaking Silesian botanist, published his magnificent 'Monographia Equisetorum' (pp. 600), and subsequently (1867) the 'Filices Europæ et Atlantidis,' including the Equiseta. Mr. J. G. Parker, F.R.S., has more recently (1887) issued from Kew a 'Handbook of the Fern Allies,' in which several of Milde's species are reduced. The object of the present paper is to place before Canadian botanists a concise statement of what is known respecting our species,—which may be enumerated as follows:—*Eq. arvense*, Linn.; *maximum*, Lam.; *pratense*, Ehrh.; *silvaticum*, Linn.; *palustre*, Linn.; *limosum*, Linn.; *ramosissimum*, Desf.; *hiemale*, Linn.; *robustum*, A. Braun; *lævigatum*, A. Braun; *variegatum*, Schleich; *scirpoides*, Michaux; —twelve in number, with several varieties and abnormal forms, and one species (*litorale* Kuhlw.) apparently attributed to Canada in error. Some of the species are widely spread over the globe, others are of more limited range. Of extra-Canadian species, three are South American, one is Japanese, one East Indian, one doubtfully distinct belongs to tropical Asia, and one is European. Of the total number of good species—twenty—we have twelve in Canada, and a reputed thirteenth.

"A map of the hemisphere of greatest extent of land was shown, with the distribution of the principal species of Eqiusetum laid down in different shades of Indian ink, the species of greatest range being shown by light shading, the others deeper according to their restriction. The Equiseta form a definite belt around the northern hemisphere, stragglers passing into South America and other parts of the southern hemisphere."

Contributions to the Bryology of the Dominion of Canada.

BY PROFS. KINDBERG AND MACOUN.

The first systematic attempt to catalogue our Canadian Cryptogams was made in 1865 by Mr. D. A. P. Watt, with the aid of Mr. Geo. Barnston, Mr. B. Billings, Prof. Macoun and myself, and the results were published at the time in

the *Canadian Naturalist*. Canada then comprised simply the two provinces of Ontario and Quebec. The lists were necessarily very incomplete, as but little attention had been paid to the Cryptogams. Nevertheless, my collection of lichens then comprised 156 species, increased shortly afterwards to 187 species; whilst Mr. Watt's list of mosses, to which Prof. Macoun was a large contributor, numbered 211 species. Since this time, Prof. Macoun has gradually increased his collection, and now, with the area of the Dominion extending from the Atlantic to the Pacific, and with the Province of British Columbia—so distinct, botanically, from the other provinces—now fairly well explored along the line of railway by him and others, he has been able to present a catalogue of 467 species of mosses, all indigenous to the Dominion, and many, as among the higher forms of plant life, peculiar to the Rocky Mountains and the Pacific coast. Of these, 41 are new to science and are fully described in the paper by Prof. Kindberg, whilst 27 others are new to America, and, with the localities of occurrence, are given below, as interesting from a geographical point of view :—

IN NOVA SCOTIA.
- *Andræa alpestris*, Schm.
- *Sphagnum medium*, Limp.

AT GASPE OR ANTICOSTI.
- *Pottia intermedia*, Turn.
- *Webera gracilis*, Schl.
- *Bryum Archangelicum*, Schm.
- *B. elegans*, Nees.
- *Hypnum Vaucheri*, Lesq.
- *Bryum contextum*, Hornsch.

IN ONTARIO.
- *Hypnum Juratyka*, Schm.
- *H. Sommerfeltii*, Myr.
- *Fissidens puscellus*, Wills.

ON ROCKY MOUNTAINS.
- *Dicranum congestum*, Lindl.

ON ROCKY MOUNTAINS.
- *Barbula angustata*, Wils.
- *Bryum Blindii*, B.
- *Mnium inclinatum*, Lindl,
- *Polytrichum sexangulare*, Fl.
- *Orothecium intricatum*, Hart.
- *Thudium decipiens*, De N.
- *Hypnum fastigiatum*, Brid.
- *H. Goulardi*, Schm.

IN BRITISH COLUMBIA.
- *Andræa Huntii*, Limp.
- *Barbula ruraliformis*, Besch.
- *Bryum Doni*, Grer.
- *B. murale*, Wils.
- *Heterocladium heteropterum*, Bush.
- *Pottia litoralis*, Mut.

Prof. Macoun is understood to be also engaged in investigating the lichens of Canada.

*Observations on Early Ripening Cereals.**

BY WM. SAUNDERS, DIRECTOR OF EXPERIMENTAL FARMS, OTTAWA.

"In this paper the author gave some interesting and practical results which have been obtained from the distribution, for test, of a variety of spring wheat, known as 'Ladoga' which was imported from Northern Russia in the spring of 1887. From careful observations extending over a series of years in Russia, it has been shown that wheat and other cereals ripen in less time in the northern provinces than they do in the more southern parts of that Empire, the difference in favour of the north varying from 12 to 35 days. While this may be partly attributable to the influence of light during the long summer days, there is no doubt that the cereals in the north have undergone gradual changes by which they have accommodated themselves to a shorter period of growth, and thus acquired an early ripening habit.

"Shortly after the author was appointed Director of the Experimental Farms of Canada, he opened correspondence with seed dealers in Russia with the objece of securing the earliest ripening wheats grown in that country. This correspondence resulted in the purchase of a quantity of Ladoga wheat, a variety much esteemed in Russia, but new to Canada. This wheat was grown near Lake Ladoga, north of St. Petersburgh, in lat. 69—840 miles further north than Ottawa—where the summer season is shorter than in any of the settled portions of the Northwest of Canada. A large proportion of this grain was distributed by mail in 3lb sample bags to such farmers as were found willing to test it and report upon it, the greater part being sent to Manitoba and the Northwest. The reports which have been received place the period of ripening of the Ladoga wheat on an average at from ten to fifteen days earlier than other varieties in cultivation, a difference which, if maintained, will suffice to ensure the ripening of this wheat soon enough to escape the early autumn frosts which in the past have always caused more or less injury to the crop in the Cana-

dian Northwest, and in some years caused heavy losses in many parts of that great wheat growing territory.

"The fertility of the Ladoga wheat is said to be very satisfactory, the average yield from all the returns received being 57lbs from the 3lbs ot seed, or nineteen fold.

"The quality of the wheat, which is a point of the utmost importance, is being carefully investigated and the evidence thus far obtained on this point is on the whole very satisfactory. Fuller information will be given in the next bulletin to be issued from the central experimental farm. Besides a second supply of Ladoga wheat there has been imported this year a variety of wheat known as Onega, from lat. 62°; barley from lat. 66°, and both barley and rye from lat. 67°. These latter are believed to be from the extreme northern limits at which cereals are grown in Europe in a continental climate. Early ripening cereals are also being songht from other countries, and it is hoped that by persevering effort in this direction, varieties will eventually be obtained which will ripen sufficiently early to relieve the settler in the more frosty districts from the discouragements experienced in the past, and result in extending the limits of the successful cultivation of cereals in Canada, and that thus the experimental farms may become an important aid in the settlement of these distant parts of the Dominion."

*On some remarkable Organisms of the Silurian and Lower Devonian Rocks of Acadia.**

By G. F. Matthew, F.G.S.

"In this paper are described three crustaceans and the Pteraspidian fish (*Diplaspis Acadica*), of which latter preliminary descriptions have been given in the Canadian Record of Science and in the Bulletin of the Natural History Society of New Brunswick. Further particulars are given, and figures showing the form, ornamentation and arrangement of the plates forming the dorsal and ventral armour of the fish. The species is compared with other

genera and species of Pteraspidian fishes, and a near relation to Cyathaspis shown. Remarks on the geological horizon of the species, based on the studies of Billings, Honeyman and others, are added. This species, and the Palæaspis of Claypole, found in Pennsylvania, are thought to be the oldest known forms of the family.

"Besides the description of this fish, the paper contains that of three crustaceans. One of these is a small Ceratiocaris (*C. pusillus*) from the same beds as the fish, viz., Division 2 of the Silurian series of New Brunswick. It is therefore one of the oldest species of this genus, and is remarkable for its narrow carapace and long rostrum.

"Another form described is a crustacean (*Bunodella horrida*) of the sub-class Synziphosura, allied to Bunodes, but with a small carapace and longer body. This also was found in the same beds as the fish plates.

"The third crustacean is a small species (*Erypterella ornata*) possessing features which make it difficult to say whether it should be referred to the Euripterida or Synziphosura. This species is from the plant beds of the Lower Devonian series at St. John, N.B."

*Notes on the Gold-bearing Veins of Nova Scotia.**

By E. Gilpin, Jr., F.G.S.

"In this paper, the writer, after referring to the general geological and mining accounts of the Nova Scotia gold fields, given by him in papers read before the American Institute of Mining Engineers, etc., drew attention to the conditions of folding in the district under consideration The veins occur in the anticlinal folds, and correspond in size, extent, and depth to the facilities afforded by the varying conditions of folding and pressure. Thus, veins are met thinning out in depth, and disappearing laterally, to be succeeded by other veins not necessarily in the same plane, etc.

"The relation of the veins to the strata are those of con-

formability, with the variations and exceptions caused by fracture, and subsequent movements. The district is much interrupted by masses of granite, which apparently do not affect the strata, except locally by metamorphism; and the auriferous veins, so far as the writer's experience goes, are not modified in value by their proximity. The 'pay streaks' or zones of rich ore are described at some length, and compared with those found in fissure or cross-country veins. In referring to the source of the gold in the veins, and especially in their richer portions, the facts are dwelt upon, that the proximity of the granitic masses was not the source of enrichment, nor did the veins, owing to their conformability to the strata and their limitation to the sides of the anticlinal folds, find access to underlying and possibly auriferous strata. The fact of the almost invariable presence of gold in the slate bands would lead to the belief that the gold has been concentrated locally from them, and that the pay streaks merely represent the proximity of the veins to a spot in the original strata, in which the gold had been deposited to an unusual extent. This view would necessitate the careful study and comparison of the pay streaks of the various localities before the question of deeper or 'second' pay streaks could be practically tested."

The Origin of some Geographical Features in Canada.

BY DR. ROBERT BELL.

The author first referred to the causes which had produced the basins of the great lakes of the Dominion. That of Lake Superior was said to be partly volcanic in its origin; and the immense basin of Hudson Bay had some points in common with it. These basins had been greatly enlarged by the subsequent decay and glacial erosion of the rocks on all sides.

Lake Ontario, Georgian Bay, Lakes Winnipeg, Athabasca, Great Slave and other large lakes of Baffin Land, occupied geographical positions resembling one another.

They all lie between the Archæan rocks and the newer strata dipping away from them. The glaciers of former times descending from the higher grounds of the former against the upturned edges of the softer rocks, tore them up rapidly and carried away the debris, thus leaving the lake basins. But when the glaciers moved from the strata lying upon the Archæan nucleus so as not to tear their edges, then no channels or basins were excavated.

Lakes Erie, Huron, Michigan, Manitoba and Winnipegosis lie in basins worn out of soft strata, dipping at low angles, with harder beds above and below them, which form their margins.

The lake region of North America was almost a continental plain but little elevated above the sea, and hence some of our great lakes lie on or near the water-sheds. Lake Superior is near the highest part of this plain, and the water flows from near its margins to the west, north and south, and its outlet is to the east. By a small artificial cut at Chicago, Lake Michigan discharges into the Mississippi as well as the St. Lawrence, and Lake Huron is on the same level.

Dr. Bell next pointed out the important part played by dykes of greenstone, etc., in producing the original cuts which, by the decay and erosion of the rocks, form the channels of rivers, arms of lakes and fiords on the sea coasts. Parallel faults or dislocations have the same effect. Other river channels, such as those of the northern branches of the Ottawa between Mattawa and Montreal, are excavated along the softer bands in the crystalline rocks.

The thousands of lakes, many of them of considerable size, scattered over the vast Laurentian regions of Northern Canada, were regarded as due to the deep decay of these rocks by long continued atmospheric causes and the subsequent sweeping away of the softened rock by glacial and other denuding agencies. These lakes all lie in rock basins, and, owing to the generally level nature of the country, many of them have two outlets. They are often shallow and full of islands, running in chains, their arrange-

ment and the directions of the bays and points depending on the combined effect of cleavage, stratification and the course of the drift.

The formation of the deep valleys in which the rivers flow in the prairie country was explained, and also the cause of the formation of the ridges and valleys in the continuation of the Appalachian structure in the Eastern Townships and in Gaspé.

*On Some Relations Between the Geology of Maine and New Brunswick.**

BY PROFESSOR L. W. BAILEY.

"This paper contains a review of the geology of the border region of Maine and New Brunswick, as based upon the investigations of the Geological Survey of the latter province during the last twenty years, its purpose being to show more particularly what conclusions of general importanee as to this region may be regarded as fairly established, what points are still doubtful, and in what ways the ascertained geology of New Brunswick may be thought to throw light, not only upon that of Maine, but also of the whole of New England.

"After pointing out the importance which the position of the province gives it as a geological indicator, and the fact that this is greatly enhanced by the comparatively large number of fossiliferous horizons recognizable within its limits, a review of the successive formations as passed over in a section from south to north along the boundary line is given, the main points discussed being (1) the Silurian rocks of Passamaquoddy Bay and their relations to the associated formations, with comments upon observations recently made in that vicinity by Prof. N. S. Shaler (*Am. Jour. of Sc.*, July, 1886); (2) the age of the slates and granites which traverse central New Brunswick and pass into Maine along the course of the St. Croix River, the slates being regarded as consisting partly of Cambro-Silurian and partly

of Silurian strata; and (3) the Silurian system of Northern New Brunswick, Maine and Southern Quebec. Comparisons are instituted between the rocks of Lake Temiscouata, in the last named province, and those of Aroostook County, Maine, and large areas of the latter, regarded in the Maine reports as Devonian, are shown to be Silurian. Attempts are, at the same time, made to establish more clearly the equivalency of different portions of the Silurian system, and lists of fossils are given, indicating horizons ranging from the Medina and Clinton to the Lower Helderberg formations."

*On Nematophyton and Allied Forms from the Devonian (Erian) of Gaspè and Baie des Chaleurs.**

BY D. P. PENHALLOW, B.SC., WITH INTRODUCTORY GEOLOGICAL NOTE BY SIR WILLIAM DAWSON, F.R.S., ETC.

"The paper stated the facts relating to the original discovery of these plants by Sir William Logan, their geological relations, and the original description of the specimens, with notices of recent exhaustive microscopic examinations of the original specimens and slides recently prepared, and comparisons of these curious plants with allied forms and associated remains of plants. It would appear that these remarkable trees, while evidently plants of the land, though growing in swamps or on the borders of the sea, have structures not now found in arboreal plants, but rather resembling those of algæ and lichens. It was pointed out that this is parallel to the fact seen in the giant Lycopods and Equisetums of the Carboniferous, that ancient forms of vegetation, with few kinds of tissue, emulated the size and complexity of modern Exogens. Nematophyton seemed to be a survival to the time of the Lower Devonian, of a type of tree peculiar, with others akin to it, to the oldest ages of the earth's history. The paper discussed the question as to the probable connection of this plant with the strange seeds or spore-cases named *Pachytheca*, by

Hooker, and *Aetheotesta*, by Brongniart. These were probably its fruits. The long, narrow leaves named *Cordaites angustifolia* may have belonged to the plant, though there is yet no certain proof of this. There is also a probable connection between Nematophyton and the resinous matter found in flakes and patches on the beds in which these singular plants occur. For the curious and complex structures of the stems, reference must be made to the paper itself, and to the figures which illustrate it. These plants are not found higher than the Lower Devonian, on the one hand, and the base of the Silurian, on the other; but they will probably be traced farther back. The associates of Nematophyton in the beds in which it occurs are *Psilophyton*, *Arthrostegma*, *Leptophleum*, and a few other forms, all characteristic of the lowest Devonian beds."

*Note on the Preliminary Examination of a Collection of Cretaceous Plants from Port McNeill, Vancouver Island.**

BY SIR WILLIAM DAWSON, F.R.S., ETC.

"The plants in question were collected by Dr. G. M. Dawson, F.G.S., of the Geological Survey of Canada, from beds believed to be on the horizon of those of Nanaimo and Comox, or perhaps a little newer. They include a number of apparently new and interesting forms besides others similar to those in the last mentioned localities. The notice is intended to indicate the general features of the collection in advance of more detailed descriptions, which will probably be ready in time for the next meeting of the Society, but not for insertion in the Transactions of the present year. At present it may be stated that the collection has many species in common with the Cretaceous of Nanaimo, and nearly resembles the Upper Cretaceous plants of Atané and Patoot, in Greenland."

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY.

The third monthly meeting was held on Monday, January 30th, the President, Sir William Dawson, in the Chair.

The minutes of the last monthly meeting were read and confirmed.

The Hon. Curator reported the following donations:—"Flying fish and West Indian Bat," from Mr. Chas. T. Hart.

Mr. A. H. Mackay, of Pictou, N.S., was elected a corresponding member.

Mr. J. H. R. Molson took the chair at the request of Sir William Dawson, who now exhibited a cast of the new trilobite (*Paradoxides regina*) recently discovered by Mr. Matthews in the Cambrian of New Brunswick, remarking on its great size and the importance of its discovery. He also read a paper on "Fossil Sponges in the Peter Redpath Museum," referring to certain sponges discovered at Little Metis, describing one of them as a species of Protaspingia, and explaining its form and structure in comparison with other sponges, recent and fossil.

Sir William was, on motion of Dr. Mills, seconded by Mr. Beaudry, accorded a hearty vote of thanks for his interesting paper.

The fourth monthly meeting was held on Monday, February 27th, Sir William Dawson in the chair.

The minutes of the last meeting were read and adopted.

The following donations were reported by the Hon. Librarian:—Chemical Reports & Memoirs, 1848, by Thos. Graham, from Mr. E. T. Chambers; Report of the Geological Society, 2 Vols., from Rev. Dr. Smyth; The Scientific American & Supplement for 1887, from Mr. J. A. N. Beaudry. The Hon. Curator reported a donation of 40 Photographs taken in Cuba, from Dr. Wolfred Nelson.

Sir William Dawson read a letter from Dr. Molson, thanking the Society for his election as a corresponding member.

A letter of resignation was read from Dr. T. Sterry Hunt.

It was moved by Prof. T. Wesley Mills, and seconded by Dr. J. Baker Edwards, and

Resolved,—That Dr. T. Sterry Hunt be elected an Hon. member, and be requested to allow his name to be continued on the list of Vice-Presidents, and that this resolution be accompanied with the best wishes of the Society and the hope that he may soon be able to resume his active connection with its work. Carried.

The following members were balloted for and elected:—Dr. Wm. A. Conklin, corresponding member; Dr. W. Johnston, Rev. Jno. Williamson, Chas. T. Hart, F. W. Evans, ordinary members.

Mr. A. McGill's paper on "Water Analysis" was now read by Mr. Joseph Bemrose. A vote of thanks was tendered.

In the absence of Mr. G. M. Matthew's paper on "Cambrian Rocks," it was moved by Dr. Edwards that it be taken as read, as it was being printed in the Record.

The sixth monthly meeting was held on Monday, March 26th, the President, Sir William Dawson, in the chair.

The minutes of the last monthly meeting were read and confirmed.

The following donation was received from Mr. Ernest Ingersoll:—Eggs of Swamson's Buzzard, the Tropic Bird, and Bells Virio; also Unio Shells from East Tennessee, etc (several species).

Mr. H. M. Ami, of the Geological Survey of Canada, now read his paper on "Fossils of the age of the Utica Shale, from Murray Bay."

Sir William Dawson made interesting remarks on the above paper, and tendered the thanks of the Society for same.

The seventh monthly meeting was held on Monday, April 23rd, the President, Sir William Dawson, in the chair.

R. W. McLachlan acted as Secretary in the absence of Mr. Holden.

The minutes of last meeting were read and approved.

The Hon. Treasurer reported progress with the special collection for liquidation of the debt.

Donations of an embroidered buffalo skin and a number of books from Mr. Ingersoll were announced.

Dr. John Rae's paper on "Some of the Birds and Mammals of the Hudson Bay Territories and the Arctic Coast," and a paper by Dr. Anderson on "Chicago Boulder Clay," were read by the President.

The thanks of the Society were tendered for these.

Annual Meeting.

The annual meeting of the Natural History Society was held on the 28th of May, Sir William Dawson, President of the Society, occupied the chair, and delivered the following address:—On the present occasion I think it may be well, by way of variety, to deviate somewhat from our usual custom, and to make some general remarks on the use and function of a society of this nature in the midst of a busy mercantile and manufacturing community, and in a province in which an interest in science is, to say the least, very scantily diffused. When in 1855 I began the educational work, which I have ever since been carrying on here, I regarded the existence of this society at that time with a small membership, but with some able men in its ranks, and with a very valuable museum, as a great encouragement and aid in the introduction of the study of natural science. In some respects I have not been disappointed. The collections of this society were of essential use to me in all the early days of my teaching here. The lectures and meetings and field-days have formed rallying points for our young devotees of natural science. The Society was the means of sustaining the Geological Survey in its earlier struggles, and it was the agency by which the American Association for the Advancement of Science was invited to this city in 1857—a movement which not only brought together a larger number of British and American and Canadian men of science than any previous assemblage,

but which paved the way for the later and more remarkable gathering of the British Association in Montreal in 1884. That these enterprises of our society have had a marked effect in the development of science, not only in Montreal, but throughout Canada, no one can doubt. When I look at the long series of our proceedings, extending from 1856, in the *Canadian Naturalist and Geologist*, and subsequently the CANADIAN RECORD OF SCIENCE, I have another measure of our power for good. The *Canadian Naturalist* was originally planned and issued by a man of rare power and gifts, the late Mr. Billings. When Sir William Logan wisely invited him to Montreal to take the position of palæontologist to the Geological Survey, he became associated with this society, and transferred the infant publication to its fostering care. Through many vicissitudes and difficulties it has continued to be published; and we may point to its volumes as a repertory of the natural history and geology of this country, which stands unrivalled as a collection of information on these subjects, since it includes not merely the original papers submitted to this society, but abstracts and notices of most of the papers and publications on Canada issued elsewhere. No scientific library, in which it is proposed to represent the natural history of that great section of North America which belongs to this Dominion, can afford to be without these volumes. By means of them also, and the separate copies of papers everywhere distributed, Canada is very widely known to scientific men abroad, and though we cannot, in detail and magnitude, rival the publications of the Geological Survey, I believe we have, with our comparatively slender means, done nearly as much to make the natural resources and productions of our country known abroad. We have, besides, furnished an early and convenient means of publication to many of the more important discoveries of the officers of the Survey themselves, as well as to amateur and private workers in natural history fields. The RECORD OF SCIENCE appeals to only a small circle of readers in this province. but it is widely known and read abroad. Our regular

monthly meetings are, as is usual with societies of this kind, slenderly attended. I feel, however, that if the real interest of the papers and of the discussions upon them was better understood by the public, we should have large houses to listen to them. Scarcely any meeting of this society fails to produce some paper or discussion or specimen of great interest to all intelligent persons, and often of vast practical importance. Very many valuable suggestions, bearing on the advancement of material interests and on subjects important to the health and welfare of the community, have originated in this room. A very different statement in regard to attendance may be made respecting our annual Sommerville lectures. These have always been popular, and have attracted large and interested audiences. More especially in recent years, since the lecture committee, under the presidency of Dr. Harrington, has adopted the excellent practice of providing a connected course bearing on some one subject of general interest, they have assumed a higher educational and practical function. The course of last year on physiological subjects was of intense interest and of great public value. That of the present session on "Climate," and this more especially in connection with the climate of Canada and of the vast districts in the North-West, now being opened up for settlement, was in another way equally important. The wise benefaction of Mr. Sommerville, as administered by this Society, has proved a centre and source of mental illumination, and has been conspicuous among us as the only endowment of a course of popular scientific lectures always able and interesting, and entirely free to all. In a country like Canada, changes are constantly taking place in the indigenous and introduced fauna and flora as culture extends—changes which are soon forgotten and of which often no record remains, while rare visitors or occasional natural phenomena or accidentally discovered specimens are being continually lost to science in the hurry of active life. From such losses and untoward accidents, our museum is a means of refuge. It has treasured thousands of specimens which would other-

wise have disappeared, has been a place of refuge and safe-keeping to evidences of rare natural phenomena, and has furnished, in a form accessible to all, classified collections of natural objects of immense value to the scientific student. It would be easy to find in our collections specimens of animals and plants once common on this island or even within the limits of this city, and now locally extinct. It is interesting to see in the old botanical collections of Dr. Holmes, one of the founders of this society, plants credited to swamps on Craig street, and to examine skins of wild animals captured in places where no hunter will again find them till Canadian civilization has passed away and the sites of our towns and farms shall have reverted to the original wilderness. So the traveller may see in our cases the rude implements and manufactures of that aboriginal city of Hochelaga, which preceded Montreal, and was visited 300 years ago by the intrepid yet courteous Cartier, but which has been finally swept away by the encroachments of our streets and terraces of houses. Our collections are relatively small, but in some departments, as in Canadian mammals, birds and insects, they are very complete, and not only afford means of study to the naturalist, but tend to inspire the young with an interest in natural objects. Their value in this respect is also enhanced by the foreign specimens which have been presented to us, and which illustrate some of the most strange and beautiful creatures of foreign lands. Such a museum is more than a mere curiosity shop; it is an actual and arranged presentment of Nature, loved and cared for and augmented by zealous and enthusiastic souls, who, actuated only by affection for Nature and by public spirit, have devoted time and labor to its maintenance, preservation and extension. The report of our honorary curator, Mr. Mason, to whom we are very much indebted for the improvements he has introduced, shows many important donations in the past year and a large number of visitors. Our library is, perhaps, the least advanced part of our equipment. Still we have a large number of valuable and rare scientific books, more especi-

ally the publications of societies abroad, and some of which are not accessible elsewhere in this city. Much has been done of late years by our honorary librarian, Mr. Beaudry, and by the library committee in enlarging our library and binding its numerous periodical publications, but the Society has always lacked the means to develop its usefulness in this direction. In the last session the Society has well sustained its work in the reading and in the publication of papers. I may mention among these the interesting *résumé* by Dr. T. Wesley Mills of the work of the American Association in 1887, and papers by him on important physiological subjects; the papers by Mr. A. T. Drummond on the Prairies of Manitoba and on the Geographical and Geological Relations of British North American Plants; those of Prof. Penhallow on Physiological Botany; that on Fossil Sponges by Dr. Hinde and myself; those on Cambrian and Siluro-Cambrian Fossils by Mr. Matthew and Mr. Ami; Dr. Rae's interesting Notes on Mammals and Birds of the Hudson's Bay Territories, and an important contribution on Water Analysis by Mr. McGill, and on the Climate of the Northwest by Mr. Ingersoll; New Species of Fresh-water Sponges from Newfoundland by Mr. McKay, and a paper on a Destructive Visitation of Field-mice in Nova Scotia by Rev. Dr. Patterson. A number of other subjects, however, occupied our attention at the monthly meetings, and will be found in the RECORD OF SCIENCE. By way of practical conclusion, I need not hesitate to affirm that what the Society has done with very slender means might be largely increased if more ample resources were provided, and that both our fellow-citizens and the Provincial Government are called upon to lend us their aid. It has been well remarked that in societies of this kind the actual work is done gratuitously by scientific laborers who ask for no public recompense, and that all that the state and the general public are called on to do is that smaller part which consists in affording means of publication. No work for the public benefit is so cheaply and economically accomplished as that of scientific societies, and it is for this reason that such societies are so

liberally subsidized in all civilized countries. The benefits flowing from the operations of the great scientific societies of the mother country are of incalculable public value and not to be measured at all by the aids which they receive. In this country in our more limited sphere it is the same; and the useful work of a society like this is limited only by the resources placed at its disposal. In the winter of 1856-7 I had the honor to deliver the introductory course of the Sommerville lectures, and as the audience of that evening has mostly passed away, I may be excused for quoting some sentences at the conclusion of this address. The subject was Natural History in its educational aspects, understanding by education that most practical and useful of all arts which develops men and women fitted to occupy useful and honorable places in the world and to minister not only to their own comfort and happiness but to those of others:—

"Natural History, rising from the collection of individual facts to such large views, does not content itself with merely naming the objects of nature. A naturalist is not merely a man who knows hard names for many common or uncommon things, or who collects rare and curious objects, and can tell something of their habits and structures. His studies lead him to grand generalizations, even to the consideration, in part at least, of the plans that from eternity existed in the infinite mind, and guided the evolution of all material things. Natural history thus rises to the highest ground occupied by her sister sciences, and gives mental training which in grandeur can not be surpassed, inasmuch as it leads her pupils as near as man may approach, to those counsels of the Almighty in the material universe, which are connected, at least by broad analogies, with our own moral and religious interests.

"It follows from the preceding views that the study of nature forms a good training for the rational enjoyment of life. How much of positive pleasure does that man lose who passes through life absorbed with its wants and its artificialities, and regarding with a 'brute, unconscious gaze,' the grand revelation of a higher intelligence in the outer world. It is only in an approximation through our Divine Redeemer to the moral likeness of God, that we can be truly happy; but of the subsidiary pleasures which we are here permitted to enjoy, the contemplation of nature is one of the best and purest. It was the pleasure, the show, the spectacle prepared for man in Eden, and how much true philosophy and taste shine in

the simple words, that in that paradise, God planted trees 'pleasant to the sight,' as well as 'good for food.' Other things being equal, the nearer we can return to this primitive taste, the greater will be our sensuous enjoyment, the better the influence of our pleasures on our moral nature, because they will then depend on the cultivation of tastes at once natural and harmless, and will not lead us to communion with, and reverence for merely human genius, but will conduct us into the presence of the infinite perfection of the Creator.

"I have sought to magnify the office of this society, on educational grounds alone; but I cannot conclude without reminding you that natural science has its utilitarian aspects. All our material wealth is founded on the objects of natural history. All our material civilization consists of such knowledge of these things, as may give us mastery over their uses and properties. Such knowledge is every day finding its reward, not merely in the direct promotion of the happiness of the possessor, but in enabling him to add to the comforts of our race, or to diminish the physical evils to which they are exposed. Into this subject, however, I cannot now enter; and this is the less necessary, since the minds of nearly all intelligent men are sufficiently alive, at least, to the utilitarian value of the natural sciences."

Report of Chairman of Council.

Mr. John S. Shearer then submitted the report of the council, as follows:—

The Council of the "Natural History Society," beg to submit the following report:—

The Session just closed, has been one of much interest and valuable research. The routine business has been regularly performed during the year. Seven regular and three special meetings of the Council have been held, and there have been six regular meetings of the Society, at which papers of great interest were read.

The progress of the Society in membership has not been equal to last year, only twelve ordinary and four corresponding having been elected.

The Library has received considerable attention from the Chairman and Committee, and is now in a fairly satisfactory condition.

The building of the Society is in good order, and a new furnace was put in last winter at a cost of $200.

The hall has again been rented to the congregation worshiping there, at the same rental as last year, the agreement being signed by Mr. T. M. Taylor.

The Provincial Government granted the Society last year $400, in place of $800, the amount which was expected. This reduction in the amount promised us, (and upon which we depended) greatly interfered with the efforts of the editing committee, who are, however, deserving of praise, for the manner in which they have issued the RECORD OF SCIENCE.

At the last meeting of Council, a committee was appointed by of the Society, to draw up a petition, and forward the same to the Hon. Honoré Mercier, Premier of the Province of Quebec, asking the Government for the amount of the *original* grant to the Society of $1,000. The petition was duly completed and forwarded on the 18th of this month, An answer has been received by the Recording Secretary, acknowledging its receipt by the Premier, and stating, that it had been handed to the Rev. Curé Labelle, Assistant Minister of Agriculture and Colonization, for his consideration and attention.

The Annual "Field Day" was held on the 4th of June last, the enterprising village of St. Jerôme having been selected for the occasion. About 100 ladies and gentlemen, started by train from Dalhousie Square Station, C. P. R., to enjoy the day's outing. It is not necessary to go into details here, tails, as a very graphic description of the day has alreody appeared in the RECORD OF SCIENCE, On our arrival at the Montreal station a resolution was passed, thanking Mr. Tuttle, and other officers of the C. P. R., for the courtesies and hospitable treatment, receceived at their hands. In connection with the above, at a meeting of Council held on the 9th day of June 1887, a resolution was unanimously adopted, and sent to W. C. Van Horne, Esq., Vice-President of the C.P.R., tendering to him the cordial thanks of the Society, for having contributed in so large a manner to

make our "Field Day" one of the most interesting and enjoyable in the history of the Society.

The usual course of Sommerville Lectures, six in number, was delivered last winter to large and appreciative audiences, affording those present much pleasure and profit. The museum was open to the public in the evening for one hour before the commencement of the lectures. The subjects, with the names of the lecturers, were as follows:—

Thursday, Feb. 16th—"Climate in Geological Time." By Sir J. W. Dawson, F.R.S., C.M.G.

Thursday, Feb. 23rd—"Climate; the present Atmospheric Conditions of the Globe." By Professor C. H. McLeod, M.A.Sc.

Thursday, March 1st—"Climate in relation to Vegetation." By Professor D. P. Penhallow, B.Sc., F.R.S.C.

Thursday, March 8th—"Weather Probabilities." By Charles Carpmael, M.A., F.R.S.C.

Thursday, March 15th—"The Climate of the Canadian West." By Ernest Ingersoll, Esq.

Thursday, March 22nd—"Climate in relation to Health." By Dr. T. G. Roddick.

The thanks of the Society are certainly due to the distinguished gentlemen, who so kindly delivered the lectures last winter, and to those who contributed to the Museum during the year.

On the 29th January, 1883, through the efforts of the Rev. Robert Campbell, the late Mr. Marler was appointed one of a committee of three to collect funds for a monument to the late Rev. James Sommerville (the founder of the Sommerville Lectures), in Mount Royal Cemetery. Nothing was done in the matter until last year, when the Rev. Dr. Campbell, Mr. A. MacNaugton and the Chairman of Council, succeeded in collecting sufficient funds from members of this society, and others, to put up a monument, with an appropriate inscription, to mark the resting place of one of Montreal's early benefactors. It will not be out of place for me in connection with the above to quote a few words delivered in this hall sometime ago by our honoured President. He says: "Such men are few and deserve commemoration, and it may be well to think also of the fact that, in bearing them in remembrance, we stimulate others to like

noble deeds. Among the many ways open to those who desire beneficially to connect their names with the real progress of this country, none is more fruitful than to follow in the footsteps of Mr. Sommerville, and to aid societies like this, in educating the people by free popular lectures."

The Librarian, Mr. J. A. U. Beaudry, then presented a report on behalf of the Library Committee, showing that much work had been done during the year and that the condition of the library was greatly improved.

The Treasurer, Mr. P. S. Ross, also submitted his annual statement with regard to the financial condition of the Society.

The following officers were elected for the ensuing year:

President—Sir William Dawson.

Vice-Presidents—Sir Donald A. Smith, Messrs. Edward Murphy, J. H. Joseph, Dr. Harrington, J. H. R. Molson, J. S. Shearer, Rev. Dr. Campbell, Geo. Sumner and Dr. J. B. Edwards.

Members of Council—Messrs. A. T. Drummond, Joseph Bemrose, Samuel Finley, Dr. Hingston, W. T. Costigan, Dr. T. W. Mills, J. S. Brown, M. Brissette and Dr. Lapthorn Smith.

Honorary Curator—Mr. Alfred H. Mason.

Honorary Corresponding Secretary—Prof. Penhallow.

Honorary Recording Secretary—Mr. A. Holden.

Treasurer—Mr. P. S. Ross.

At a subsequent meeting of Council, held June 4th, Mr. Samuel Finley was elected Chairman of Council, and the following committees were appointed:—

Editing Committee—Prof. Penhallow, *Chairman;* Dr. Harrington, Dr. T. Wesley Mills, A. T. Drummond, Joseph Bemrose.

Lecture Committee—Dr. Harrington, *Chairman;* Rev. Dr. Campbell, P. S. Ross, A. H. Mason, Dr. J. Baker Edwards.

Library Committee—E. T. Chambers, *Chairman;* J. A. U. Beaudry, F. B. Caulfield, R. W. McLachlan, Joseph Fortier.

House Committee—J. S. Shearer, *Chairman;* J. A. U. Beaudry, J. H. Joseph, Samuel Finley.

Membership Committee—J. Stevenson Brown, Albert Holden, S. Finley, P. S. Ross, J. A. U. Beaudry, Dr. J. Lapthorn Smith, George Sumner, W. T. Costigan.

ANNUAL FIELD-DAY, 1888.

The annual field-days of the Natural History Society are looked forward to by many lovers of Nature with much pleasurable anticipation, and have always been enjoyable events, that of June 18th, 1888, being no exception to the rule. The day was glorious and the choice of locality admirable, being the grounds of Hon. Mr. Papineau at Montebello. The party left Montreal by special train from Dalhousie Square Station, and consisted of Prof. Harrington, Prof. Bovey, J. H. R. Molson, J. S. Shearer, George Sumner, S. Finley, Albert Holden, J. S. Brown, Hollis Shorey; Mr. Gibb, of Abbotsford; Capt. R. C. Adams, R. Miller, J. Henderson, Mrs. J. H. R. Molson, Miss Hill, Miss Cordner, Mrs. and Miss Baylis, Mrs. Lewis, Miss Dawson, Miss K. Drummond, Mrs. E. Day, Mrs. H. B. Stephens, Mrs. and Miss Finley, Miss Botterell, Miss Van Horne, Miss A. Van Horne, Mrs. Adams, Mrs. Sumner, Mrs. Shearer, Mrs. and Miss Ritchie, Miss Evans, Miss Henderson, Mrs. Salter, and many others. Sir William Dawson was unavoidably absent, owing to duties in connection with the recognition of McGill degrees in the provincial examinations for the legal and medical professions.

On the arrival of the party at Montebello at noon, they were joined by a contingent from the Ottawa Field Naturalists' Club, including Mr. J. F. Whiteaves, F.G.S., and Mr. H. Ami, F.G.S.. On arriving at the grounds they were met by Mr. Papineau, who received them with the greatest cordiality and kindness.

The grounds are extensive and laid out with much taste, the prevailing principle being evidently to preserve the natural beauties, and this has been done most skilfully. In a separate building, resembling a chapel somewhat in appearance, is contained a large collection of curiosities, historical paintings, family relics and *objets d'art*. A visit was paid to it by the members, and Mr. Papineau kindly

gave particulars concerning many of the paintings and other objects.

Parties were then formed for the usual collection of geological, entomological and botanical specimens. The geological party was in the hands of Prof. Harrington, the botanical under Mr. Gibb, the entomological under Mr. Albert Holden; and all set about their work enthusiastically. Others dispersed themselves about the grounds in little coteries, and enjoyed more quietly the varied beauty of the site. The broad expanse of the Ottawa with its dark waters, the varied green foliage of the trees, the winding walks with their rustic seats in charming nooks, all formed a most charming *coup d'œil.* The collecting parties having returned to the manor loaded with spoils, a very hearty vote of thanks (on motion of Mr. J. H. R. Molson, seconded by Prof. Bovey) was given to Mr. Papineau, who made a very neat reply. Farewell was then said, and the party returned to the station. Here an agreeable surprise was in store for them, for a car specially fitted up and prettily decorated with flags, hanging baskets, &c., had been added to the train, and the party were invited by Messrs. A. C. and W. S. Burgess, who were in charge, to a most *recherché* repast as the guests of the railway company.

On the homeward journey the results of the competition for prizes were announced as follows :—

BOTANY (unnamed Collections of Plants)—First prize, Miss Baylis, 67 species; second prize, Mrs. Edmund Day, 62 species. Honorable Mention—Miss M. Van Horne, 59 species; Miss G. Finley, 56 species.

ENTOMOLOGY (named Collections)—First prize, A. F. Winn, 57 species; second prize, J. F. Hansen, 32 species.

ENTOMOLOGY (unnamed)—First prize, E. F. Baynes, 41 species; first prize, W. C. Adams, 41 species. Honorable Mention—E. C. Trenholme, 34 species.

GEOLOGY (named Collection)—Prize, Miss Blanche Evans, B.A.

GEOLOGY (unnamed Collection)–Prize, Miss A. Van Horne.

On arriving at Dalhousie Square Station, a hearty vote of thanks was passed to the Canadian Pacific Railroad officials for their courtesy.

(*From the Proceedings of the Geological Society of London, May* 23, 1888).

(ABSTRACT).

"On the Eozoic and Palæozoic Rocks of the Atlantic coast of Canada in comparison with those of Western Europe and the Interior of America." By Sir J. W. Dawson, LL.D,, F.R.S., F.G.S.

The Author referred to the fact that since 1845 he had contributed to the Proceedings of the Geological Society a number of papers on the geology of the eastern maritime provinces of Canada, and it seemed useful now to sum up the geology of the older formations and make such corrections and comparisons as seemed warranted by the new facts obtained by himself, and by other observers of whom mention is made in the paper.

With reference to the Laurentian, he maintained its claim to be regarded as a regularly stratified system probably divisible into two or three series, and characterized in its middle or upper portion by the accumulation of organic limestone, carbonaceous beds, and iron-ores on a vast scale. He also mentioned the almost universal prevalence in the northern hemisphere of the great plications of the crust which terminated this period, and which necessarily separate it from all succeeding deposits. He next detailed its special development on the coast of the Atlantic, and the similarity of this with that found in Great Britain and elsewhere in the west of Europe.

The Huronian he defined as a littoral series of deposits skirting the shores of the old Laurentian uplifts, and referred to some rocks which may be regarded as more oceanic equivalents. Its characters in Newfoundland, Cape Breton, and New Brunswick were referred to and compared with the Pebidian, &c., in England, The questions as to an Upper Member of the Huronian or an intermediate series, the Basal Cambrian of Matthew in New Brunswick, were discussed.

The very complete series of Cambrian rocks now recognized on the coast-region of Canada was noticed, in connection, with its equivalency in details to the Cambrian of Britain or Scandinavia, and the peculiar geographical conditions implied in the absence of the Lower Cambrian over a large area of inferior America.

In the Ordovician age a marginal and a submarginal area existed on the east coast of America. The former is represented largely by bedded igneous rocks, the latter by the remarkable series named by Logan the Quebec Group, which was noticed in detail in connexion with its equivalents further west, and also in Europe.

The Silurian, Devonian, and Carboniferous were then treated of and detailed evidence shown as to their conformity to the types of Western Europe rather than to those of America.

In conclusion, it was pointed out that though the great systems of formations can be recognized throughout the Northern Hemisphere, their divisions must differ in the maritime and inland regions, and that hard and fast lines should not be drawn at the confines of systems, nor widely different formations of the same age reduced to an arbitrary uniformity of classification not sanctioned by nature. It was also inferred that the evidence pointed to a permanent continuance of the Atlantic basin, though with great changes of its boundaries, and to a remarkable parallelism of the formations deposited on its eastern and western sides.

Discussion.

The President, whilst recognizing the importance of the paper, doubted whether the question of correlation of the Pre-Cambrian rocks on either side of the Atlantic was ripe for discussion.

Dr. Hicks felt sure that the paper would be welcomed on this side of the Atlantic. He agreed with most of the conclusions of the Author, including the correlation of the Huronian with the Pebidian. This was borne out, not only by similarity of lithological characters, but by the exact correspondence of the succeeding beds in the two areas as shown by Mr. G. F. Matthew. The difficulty of correlation lay with the rocks below the Huronian. He noticed that fragments of granitoid rocks occurred in the Huronian as in the Pebidian. He had also called attention to the contrast between the Palæozoic rocks of the ocean borders and those of the interior of the continents, in papers read before the Society and elsewhere.

Dr. Scott referred to Mr. Walcott's work, and mentioned the occurrence of great deposits of Pre-Cambrian rock in Arizona. Where terrestrial species play an important part, difficulties of correlation were much increased.

Dr. Hinde noticed the difference between the coast-geology of America and that of the interior.

Mr. Marr stated that the paper referred very fully to the point noticed by the last speaker.

(From the Annals of the New York Academy of Science, Vol. IV., No. 4, 1888.

ON AN ARCHÆAN PLANT FROM THE WHITE[1] CRYSTALLINE LIMESTONE OF SUSSEX COUNTY, N.J. BY N. L. BRITTON.

The abundance of graphite in certain Archæan limestones, and notably in those referred to the Laurentian systems, has often been cited as an indication of the existence of plant life at that remote period, and indeed, has seemed to the writer and others, attributable to no other source, although this view has not found ready acceptance in the minds of many geologists. The mineral generally occurs in these limestones in the form of scattered separated flakes or small masses, often somewhat crystalline in outline, thus affording neither information regarding the nature of the plant from which it has been derived, nor certainty that it is in reality of vegetable origin. Through a fortunate discovery made last September by Mr. J. O. Northrop and myself, I am able to submit evidence that in one belt of Archæan limestone in the Highlands of New Jersey, the graphite has been derived from a plant, and proof that vegetable life existed in that epoch.

The plant-remains appear as black bands on the rock, consisting of very thin films of graphite; in some the thickness reaches about 0.5 mm., but it is generally less. The average width of the bands is about 3 mm., and the greatest continuous length observed about 6 cm., though it is apparent that when entire they are much longer. In many parts of the rock these are matted together to form broad black patches, which are in reality thin carbon strata. The bands and films lie parallel with the bedding of the limestone. No cellular structure has thus far been detected.

As this is undoubtedly the most ancient plant yet discovered, I should suggest for it the generic name *Archæophyton*, and to acknowledge, in an imperfect manner, my obligation to one to whom I am indebted for encouragement and counsel in study and investigation, and at the same time, to associate with this interesting plant the name of one foremost in American Palæobotany, I would denominate the plant *Archæophyton Newberryanum.*

While the imperfect nature of the fossil forbids any definite statement as to its botanical affinity, we may, perhaps, assume its relation to the algae.

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On some Canadian Rocks containing Scapolite, with a Few Notes on some Rocks associated with the Apatite Deposits.

By Frank D. Adams, of the Canadian Geological Survey, and Andrew C. Lawson, Ph. D., of the Canadian Geological Survey.

At the meeting of the British Association for the Advancement of Science, held in Montreal in the summer of 1884, a short paper entitled "On the Occurrence of the Norwegian 'Apatitbringer' in Canada, with a Few Notes on the Microscopic Characters of some Laurentian Amphibolites," was read before the Geological Section by Mr. Frank D. Adams. Only a short extract of some dozen lines was prepared for the Transactions, as it was proposed to continue the investigation of these rocks and especially to study their geological relations in the field. A thorough geological examination of the district from which these rocks were obtained has not, however, been found to be practicable, and in the following paper it is proposed to give a more detailed description of them, together with the results of the examination of a few others collected since that time.

The peculiar scapolite rock, referred to above as the "Apatitbringer," was first mentioned by Brögger and Reusch in a paper entitled "Vorkommen des Apatit in Norwegen."[1] In this paper, the authors state that at Oedegarden in Bamle (Southern Norway), where the largest apatite deposits of that country are found,—some idea of the extent of these deposits may be obtained from the fact that in 1882, at Oedegarden alone, 15,000 tons of apatite were mined, between 700 and 800 men being employed—the mineral occurs in, or in the immediate vicinity of, a rock described by them as "Geflecter Gabbro." This rock, however, differed from gabbro, as that word is generally understood, as it was stated to be composed essentially of amphibole and labradorite, and it has been shown to be a peculiar form assumed by the normal gabbro of the country on approaching the apatite veins. Referring to this work, Kjerulf, in his "Geologie des südlichen und mittleren Norwegen," after mentioning one variety of gabbro as an "Erzbringer," says:—"Der bunte oder Hornblende Gabbro......wegen seiner Rolle als 'Apatitbringer' gekannt zu sein verdient." It was also described as Hornblende Gabbro in a paper by H. Möhl.[2] Michel Lévy,[3] who subsequently examined the work, showed that, as conjectured by Lang,[4] the white mineral was really not plagioclase, but a mineral of the scapolite family, which he referred to the species wernerite. Sjögren,[5] who has more recently

[1] Zeit. d. deutsch. geol., Gesellsch, 1875, Heft III.

[2] Die Eruptivgesteine Norwegens, mikroskopisch untersucht und beschrieben. Nyt magazin for Naturwidenskaberne. Bd. XXIII.

[3] Sur une roche à sphene, amphibole et wernerite granulitique de Bamle (Norwège). Bull. Soc. Min. France. No. 3. 1878.

Sur le gisement de l'amphibolite à wernerite granulitique d'Oedegaard pres Bamle (Norwège). Bull. Soc. Min. France. No. 5. 1878.

[4] E'in Beitag zur Kenutniss norwegischer Gabbros, Z D. G. G. 1879. XXXI. 484.

[5] Om de norska apatitforekomsterna, etc. Geol. Fören i, Stock. Förh. 1883. 447.

carefully examined the rock, refers the mineral to the species dipyr, calling the rock a dipyr diorite.

It is believed by those who have studied the rock and its relations in the field, to be derived from the alteration of the true gabbro adjoining it, the pyroxene of the gabbro being altered to hornblende and the plagioclase of the gabbro to scapolite. The change would be essentially one of diagenesis. Intermediate varieties are found containing diallage "rests" in the hornblende and plagioclase mixed with scapolite.[1] In this connection, an observation made by Fouqué and Michel Lévy[2] is especially interesting, namely, that when the rock is fused and allowed to cool, the magma recrystallizes as a mixture of labradorite and augite.

The occurrence of scapolite in certain of the crystalline schists, especially augite gneiss and amphibolite, has been mentioned by Törnebohm[3], Dathe[4], Becke[5], Wulf,[6] Mügge,[7] Svedmark,[8] and others. The last-named author, in addition to a number of scapolite-bearing gneisses and amphibolites, describes an amphibolite from Orebro which contains scapolite to the exclusion of plagioclase, and which also holds a little diallage and mica. In composition, therefore, it would be closely allied to the Oedegarden rock.

Lacroix and Baret[1] have also recently described a pyroxene wernerite rock which occurs associated with gneiss

[1] See Sjögren, loc. cit., and Rosenbusch, Mass. Gest. I., 165.

[2] Sur la transformation par voie ignée, etc. Bull. Soc. Min. France. 1879. 105.

[3] Ett par Skapolitförande Bergarter. Geol. Fören. i. Stöck. Förh. 1882. VI. 192.

[4] Jahr. preuss. geol. Landesanstalt. 1884. LXXVI.

[5] Die Gneissformation des niederösterr. Waldviertels. T. M. P. M. 1882. 369.

[6] Beitrag zur Petrographic des Hererolandes in Südwest-Africa, T. M. P. M. 1887. 213.

[7] Ueber einige Gesteine des Massai-Landes. N. J. Beil. Band. IV. Heft III.

[8] Om nagra Svenska Skapolitförande bergarter. Geol. Fören. i. Stock. Förh. VII. 1884. 293.

and amphibolite at Point-du-Jour, near St. Nazaire, in France. In this rock the pyroxene is associated with, and sometimes completely replaced by, a very pleochroic amphibole, and in some specimens the wernerite is associated with oligoclase, the rock thus passing into a wernerite oligoclase amphibolite.

A most interesting paper in this connection and one which will be referred to again, was published by Dr. A. P. Coleman in the Transactions of the Royal Society of Canada for 1887.[2]

As Canada is the only country, except Norway, in which apatite is extensively mined, and as in most respects the character and mode of occurrence of the mineral in both countries are very similar, a corresponding relation to dipyrdiorite might be looked for. In Canada, however, as pointed out by Dr. Harrington in his excellent "Report on the Minerals of some of the Apatite-bearing Veins of Ottawa County, Que.[1]," this relation does not exist, the important deposits of apatite occurring associated with a granular pyroxene rock, which is always regarded by prospectors as indicative of the presence of apatite, and occupies, in that way, to a certain extent, the position of the "Apatitbringer" in Norway. "These[2] pyroxene rocks, which have been called by Hunt pyroxenites, vary considerably in their characters. Sometimes they consist almost exclusively of pyroxene, though more commonly quartz and orthoclase are present. Mica, too, is of frequent occurrence, while minute garnets may occasionally be seen. The frequent presence of disseminated grains of apatite is also an important fact. When pyroxene is the principal mineral, the rock commonly shows little or no trace of

[1] Lacroix et Baret.—Sur la pyroxénite à wernérite du Point-du-Jour près Saint-Nazaire. Bull. Soc. Min. France, July, 1887.

Lacroix, A.—Note sur une roche à wernérite granulitique des environs de Saint-Nazaire. C. R. CIV. 1011.

[2] Microscopic Petrography of the Drift of Central Ontario.

[1] Reports of Progress of the Geological Survey of Canada, 1877-8.

[2] Ibid.

bedding, but is often a good deal jointed. Its aspect, when the pyroxene is of a dark colour, is often that of a massive eruptive rock." It is very intimately associated with the apatite, in some places apparently passing imperceptibly into it.

In order to ascertain whether these pyroxenites contained any scapolite, two specimens—one from lots 35 and 36, range V. of Portland West, and the other from the well-known McLaurin Mine in Templeton—were sliced and examined microscopically. They are both rather coarse-grained, that from Portland being of a light greyish colour and holding a little disseminated apatite, sphene and pyrite, while the Templeton rock is light green in colour, and in certain places contains a good deal of biotite. Neither of them contained any scapolite, nor could any be found in the wall rock of the Emerald Mine in the township of Buckingham.

Mr. Coste, Mining Engineer to the Geological Survey of Canada, who has had occasion to visit a number of the apatite mines, considers that the apatite occurs in the form of more or less irregular veins, the above mentioned pyroxene rocks occupying the position of vein stones. He also believes that these veins of apatite and pyroxenite are found almost invariably in connection with a certain eruptive rock, which varies much in texture but is generally rather coarse-grained, and which is composed largely of orthoclase generally having a bluish or lilac tint. Two specimens of this rock, collected by Mr. Coste,—one from the "Star Hill Mine," range VIII., Portland West, in the Province of Quebec, and the other from the "Blessington Mine," lots 29 and 30, range I., Inchinbrooke, in the Province of Ontario,—were also sliced and examined. The two rocks resemble one another in appearance, that from the "Blessington Mine," however, being somewhat darker in colour.

Under the microscope, the "Star Hill" rock is seen to be composed essentially of orthoclase and biotite, with very small amounts of magnetite and pyrite. The orthoclase is almost always clear and fresh; the biotite is also very

fresh, although in places it is slightly decomposed to chlorite. The magnetite is probably titaniferous, as occasionally it is altered to leucoxene. Another hand specimen of the same rock was found to contain, in addition to the minerals mentioned above, a little quartz and a little plagioclase, and the orthoclase contained the peculiar intergrowths characteristic of perthite. This specimen had a very obscure foliation, and the quartz and orthoclase showed evidence of having been submitted to pressure. It also contained a few forms of some mineral which had been entirely decomposed, but which may have been pyroxene.

The rock from the "Blessington Mine" is composed essentially of orthoclase, biotite, pyroxene and magnetite, with a little plagioclase, hornblende, pyrite, calcite and apatite. The orthoclase contains a multitude of minute, black, rod-like inclusions and fine dust. The pyroxene occurs in large amount, and is more plentiful than the biotite. It is pale green in colour, with scarcely noticeable pleochroism and large angle of extinction. It is generally without good crystalline form, but occasionally occurs in rude crystals. It is also occasionally twinned. The hornblende occurs in very small amount—intergrown with the pyroxene and biotite. The calcite is present in small amount, and results from the decomposition of the pyroxene and feldspar. The magnetite may be titaniferous. The apatite is uniaxial and negative, and occurs in irregular shaped grains, with high index of retraction and faint bluish colour, generally associated with the pyroxene.

The rock from the "Star Hill Mine" is therefore a *mica syenite*, and that from the "Blessington Mine" an *augite mica syenite.* It will be a matter of interest to ascertain whether these rocks occupy a similar relation to the apatite at the other mines. A monograph of the apatite district of the Province of Quebec, which is now being prepared by Mr. Ingall of the Geological Survey, willl decide this and many other important points.

Among a series of specimens from the vicinity of the town of Arnprior, on the River Ottawa, which were some time

ago, sent to Mr. Hoffmann of this Survey for examination, there was, however, one small specimen which exactly resembled the Oedegarden rock, and which, when sliced and examined with the microscope, proved to be identical with it. Unfortunately, we were unable to obtain any further specimens or to ascertain the locality from which it came more precisely than that, as above mentioned, it was from near the town of Arnprior. The large collection of rocks in the museum of the Geological Survey of Canada was then carefully examined, and sections were prepared of all those which at all resembled this rock in appearance. An examination of these sections resulted in the discovery of three other specimens, from widely separated localities, rich in scapolite, but unlike the Arnprior rock, containing also a considerable proportion of plagioclase.

The first of these specimens was collected by the late Mr. Vennor at Mazinaw Lake, in the township of Abinger, in the county of Addington; the second was obtained by Mr. Coste at the Robertsville or Mississippi Iron Mine, on lot 3, range VIII. of the township of Palmerstone, in the county of Frontenac, and the third was collected by Dr. Bell from lot 28, range I. of McDougall, in the Parry Sound district. All three rocks are of Laurentian age, and come from that great stretch of Laurentian country lying north of Lake Ontario and south of of Lake Nipissing and the River Ottawa. The eastern half of this area was examined by Mr. Vennor, and found by him to be rich in amphibolites, dioritic schists and diorites; a very common, coarse-grained variety of the latter being called by him "blotched diorite," and it is associated with these dioritic rocks, whose occurrence at Mazinaw Lake is mentioned by Mr. Vennor, that the Arnprior and Mazinaw Lake rocks apparently occur. The rock from the Robertsville Mine is found associated with crystalline limestone and granite. In some places it forms the wall rock of the magnetite, between 50,000 and 60,000 tons of which have been mined. The mode of occurrence of the McDougall rock is described by Dr. Bell in the

following extracts from his report on the country north of Lake Huron and east of Lake Superior.[1]

"Eastward of the village of Parry Sound, along the road of the same name, dark, hornblendic gneiss or schist prevails for a distance of about a mile and a half. A band of crystalline limestone, and one of mottled white and black diorite, occur in association with these rocks where this road crosses lot 28, concession I., township of McDougall." "The rock which is here immediately associated with the limestone is a remarkable looking diorite, consisting of a white ground, thickly mottled with patches of dark-green or blackish hornblende, having their longer diameters arranged parallel to the general bedding. This appears to be the rock which Mr. Vennor has described in the Hastings, Lanark and Renfrew region, under the name of 'blotched diorite." The rock from near Arnprior is rather coarse-grained, and with the naked eye is seen to consist of white of bluish-white scapolite, with a rather larger amount of what looks like a dark greenish hornblende. In appearance, the scapolite closely resembles that occurring in the Norwegian rock, which has been aptly compared by Brögger to wet snow. The rock appears to have an indistinct foliation, but the specimen sent was too small to show its structure distinctly. When thin sections are examined with the microscope, the rock is seen to be fresh and almost entirely free from decomposition products. The structure is for the most part granular, none of the minerals being idiomorphic.[2] The principal constituents are found to be pyroxene, hornblende and scapolite; and the accessory ones epidote, enstatite, pyrrhotite and rutile.

The pyroxene is very light in colour and faintly pleochroic. $\mathfrak{A}$=yellowish; $\mathfrak{B}$=greenish; $\mathfrak{C}$=light green. The absorption is $\mathfrak{C} > \mathfrak{B} > \mathfrak{A}$. Basal sections show well-marked prismatic cleavages intersecting at an angle of about 90°;

[1] Reports of Progress of Geological Survey of Canada, 1876-77, pp. 199 and 204.

[2] Rosenbusch.—Mikroskopische Physiographie der massigen Gersteine. Band II. i. Abtheilung,—1886.

while in sections parallel to the clinopinnacoid, the extinction is seen to be about 39° or 40° against C. Most of the pyroxene has a peculiar, fibrous or mottled appearance, due to what is apparently its partial alteration into a light green pleochroic hornblende. This hornblende is darker in colour and generally has a shred-like character at its contact with the pyroxene, the two minerals, however, often having a sharp line of contact, which in this case is usually a cleavage trace. The various patches, streaks or shreds of hornblende scattered through an individual of pyroxene generally have a common orientation, presenting elongated forms in prismatic sections of the pyroxene, but on basal sections generally appearing as irregular spots, the hornblende strings being inlaid parallel to the C axis of the pyroxene, and sometimes also elongated parallel to ∞ P ∞, both minerals having the B axis in common.

In addition to the hornblende associated with the pyroxene, the rock contains other hornblende which shows no evidence of derivation from pyroxene. This is of a deep green colour, has the usual perfect cleavages, and occurs scattered through the rock in irregular shaped masses, which however occasionally have well defined prismatic contours. The pleochroism is strongly marked $\mathfrak{C}$=dark bluish-green; $\mathfrak{B}$=dark green; $\mathfrak{A}$=light yellowish or brownish-green.

The scapolite is abundant, and occurs in large, colourless grains. In basal sections a very distinct uniaxial figure was repeatedly obtained, and by means of the quarter-undulation plate its negative character was clearly established. The quadratic cleavage parallel to ∞ P ∞ is distinct. The polarization colours are either brilliant or are of a pale bluish-gray tint like those of the feldspars. The brilliantly polarizing scapolite occurs side by side with that which shows the soft gray tints, so that the difference does not seem to be due to a varying thickness of the section. In two instances, traces of polysynthetic lamellæ were observed, in which the extinction, though much less distinct than in plagioclase, resembled it otherwise very

strongly. The appearance was very suggestive of the derivation of the scapolite from plagioclase, and if this be the case the twinning structure of the latter is retained after the mineral has apparently been entirely changed to scapolite. Probably, however, in these cases the change may not be complete, and although the mineral has the characters of scapolite, there may be sufficient plagioclase remaining in twinning position to cause the alternate oblique extinction observed. There are in the scapolite, inclusions of a dusty, opaque character, besides fluid inclusions and microlites. The dust and fluid exclusions are disposed either in planes or irregularly; in the latter case, the section may be really parallel to the planes in which the inclusions lie. The microlites lie for the most part in cleavage lines, and have their long axes either perpendicular or oblique to certain planes (sometimes cracks) which cross the cleavages. In some instances, numerous opaque, thick plates and stout rods were observed lying parallel to the cleavage lines. When seen on edge, these plates and rods had rectangular outlines, although rounded patches of the same opaque material could sometimes be seen. Occasionally the scapolite is somewhat cloudy, owing to the presence of a kaolin-like decomposition product, but generally it is quite fresh and clear. The epidote occurs in small, nearly colourless grains of irregular shape. Scattered through both the hornblende and the pyroxene, and occasionally to be observed in larger grains situated between those of the other constituents, there are irregularly rounded or oval grains of a mineral which is referred to the rhombic pyroxenes. It is biaxial, possesses a rather high index of retraction, and polarizes in brilliant though somewhat subdued tints. It has one well-marked cleavage, to which the extinction is parallel, and has a fine, fibrous structure, also parallel to the cleavage, which seems to be due to decomposition. The mineral is not quite colourless, but has a faint purplish or amythestine tint, and occasionally seems to be slightly pleochroic. Pyrrhotite occurs very sparingly, and is distinguished by its opacity and its bronze

colour in reflected light. In one instance it was seen to be included in the scapolite, which was stained yellowish-green in the vicinity of the grain. Other grains occur bedded in the hornblende. Rutile occurs in occasional grains, rather large in size and irregular in shape, but has not been observed in its usual prismatic habit. It has a high index of retraction and a faint brownish or reddish colour, and resembles titanite very much both in ordinary light and between crossed Nichols. In convergent light, however, it gives a distinct uniaxial interference figure, and there are traces of a quadratic cleavage. It polarizes in dull, leaden-gray tints. In two instances these grains of rutile were seen to be made up of lamellæ, as if polysynthetically twinned. There was, however, no alternation of extinction corresponding to the alternate lamellæ. In a certain position between crossed Nichols, the section was broken up into these lamellæ, which were alternately light and dark. On revolving the stage through 90°, the same appearance is produced, *i.e.*, the same lamellæ are light and dark as before, and there is no position in which the light lamellæ become dark and the dark lamellæ light. In one of these two instances, the polyxenthetic lamellæ appeared to cross each other, the angle between the two sets being, as nearly as could be measured, 53°. The rutile is associated with the scapolite, and in the last-mentioned case, where the grain has a diameter of 1·4 mm., it is entirely surrounded by scapolite. In this case the glass cover having been removed, the section was treated with hydrochloric acid, the mineral, however, was quite unacted upon. Following Sjögren, the rock may be termed a *Scapolite Diorite.*

The rock from Mazinaw Lake [Museum Number 2930] is rather coarse-grained and distinctly foliated. The principal constituents are hornblende, biotite, scapolite, plagioclase and, in smaller amount, quartz. The accessory minerals are epidote, ziosite and titanite. Pyroxene does not occur in any of the slides. In nearly all the sections the rock is seen to be made up of two parts: (1) a fine-grained,

granulitic "groundmass" composed chiefly of feldspar with some quartz, biotite and hornblende; and (2) a coarser grained portion imbedded in this "groundmass," but not having any definite crystalline boundaries. The minerals composing this coarser grained portion are scapolite, plagioclase, biotite, hornblende, and occasionally quartz. A gradation between the "groundmass" and the coarser constituents can generally be observed, and in some few instances there appears to be evidence that the former was derived from the latter, particularly from the plagioclase, by crushing, the structure being cataclastic. In this connection, the absence of pyroxene is noteworthy. The scapolite is generally coarsely crystalline, and present in large amount. Only occasionally is it sparing in quantity or finely crystalline. Very commonly it occurs in large plates of uniform orientation, in which more or less elongated individuals of hornblende or biotite lie irregularly imbedded, the structure being quite analogous in appearance to the ophitic structure seen in diabases. In one case, a large plate of scapolite was observed to inclose an irregular grain of plagioclase, the latter being somewhat decomposed. The scapolite usually occurs side by side with plagioclase or with plagioclase and quartz, all being in very irregular shaped grains, evidently allotriomorphic. The line of contact between the plagioclase and scapolite is quite sharp, and generally there is but little evidence of the derivation of the latter from the former. Associated with the scapolite, there is often a fine-grained aggregate of gray decomposition products, which shows aggregate polarization in brilliant but subdued colours, and which probably consists of muscovite, calcite, etc.

Hornblende and biotite are well represented in all the sections, the former being rather more abundant than the latter. The hornblende is of a deep green colour, strongly pleochroic, and contains numerous inclusions. The biotite is of the usual brown colour, and some grains contain inclusions, in the shape of films running in between the cleavage lamellæ, of a mineral which between crossed Nichols resem-

bles scapolite, but which are so minute that their character cannot be determined with certainty. The plagioclase is usually quite fresh and clear. In the "groundmass," the feldspars are only twinned occasionally and can be distinguished from the quartz only by means of the interference figure in convergent polarized light.

The most striking of the accessory minerals, and at the same time the only constantly idiomorphic constituent of the rock, is the epidote. It occurs in elongated prisms of rhombic cross-section, which vary much in width, in some cases forming slender needles, but elsewhere being of stout columnar habit. The crystals are colourless, but between crossed Nichols, polarize in the usual brilliant manner. The extinction is parallel to the side of the prism that is to the axis, and in cross-sections is oblique to both of the crystallographic lines. The plane of the optic axes may readily be determined to be perpendicular to B. The index of retraction is high, the prisms standing out in marked relief, and irregular transverse partings can occasionally be observed. In one section a large plate of zoisite was observed. It was oblong in shape, showed a perfect cleavage parallel to its length ($\infty P \breve{\infty}$), and a distinct cross parting. The plane of the optic axes was found to be at right angles to the C axis. The mineral is colourless, and shows dull gray to deep blue polarization colours. Titanite is rare, and occurs in small, rudely wedge-shaped grains. The rock may be called a *Plagioclase Scapolite Amphibolite.*

The rock from McDougall [Museum Number, 2996,] is coarse-grained, and possesses a rather indistinct foliation. Under the microscope, it is seen to be a granular aggregate of plagioclase, scapolite and green hornblende, with a sparing amount of pyroxene and quartz and a little accessory epidote and pyrite. The plagioclase is for the most part fresh, though occasionally a little cloudy, and by means of Lévy and Pumpelly's method was found to belong to the anorthite-labradorite end of the plagioclase series. The plagioclase and hornblende are present in about equal proportions. The scapolite is less abundant, and occurs in large, irregular-shaped

plates, usually somewhat cloudy from the presence of decomposition products. The pyroxene is present in rather sparing amount, and is not seen in every slide. It is pale green in colour and without noticeable pleochroism, and is intimately associated wtth the hornblende, being in many cases apparently in process of alteration into that mineral, as in the case of the Arnprior rock. It may, perhaps, best be termed a *Plagioclase Scapolite Diorite.*

The rock from the Robertsville Mine is rather coarse-grained, and in external appearance bears a strong resemblance to that from McDougall, but possesses a more distinct foliation. Under the microscope it is seen to be composed of scapolite, plagioclase and hornblende, with accessory biotite and epidote. The scapolite is present in large amount, and is generally very free from decomposition products. It usually occurs in rather large plates, which polarize in brilliant colours. The cleavage with extinction parallel to it is well seen, and in sections parallel to the base the mineral is found to be uniaxial and negative. The plagioclase, which is also present in large amount, polarizes in much more subdued tones. Polysyntheti twinning is seen in many, but not in all cases. It is often rendered cloudy by the presence of decomposition products, which resemble kaolin in appearance, and as a general rule is not so fresh as the scapolite which occurs side by side with it. The hornblende, which is light green in colour, is without good crystalline form, but is not fibrous in character. It is strongly pleochroic, in yellowish and bluish-green tints. The biotite occurs in very small amount, intimately associated with the hornblende and partly altered to chlorite. Scattered through the plagioclase, and less frequently also in the scapolite, are many small, stout prisms and irregular grains of a colourless mineral, with high index of retraction, and which polarizes in brilliant colours. Occasionally these are pleochroic, with the yellowish tint characteristic of epidote, and have been referred to that species. The rock, which under the microscope resembles one of the crystalline schists, may be termed a *Plagioclase Scapolite Amphibolite.*

Although these scapolite rocks have been ascertained to exist at only four localities, they probably occur abundantly in various parts of the district from which these were obtained, and it is very interesting to note that in his study of the Petrography of the Drift of Central Ontario,—his materials being collected principally about Cobourg, situated about the middle of the southern limit of this same district,—Dr. Coleman found several specimens of "scapolite-diorite schist," which, judging from his description, must be identical in character with the rocks described in this paper.

Although the derivation of at least a part of the hornblende of these rocks from pyroxene is well nigh certain, the derivation of the scapolite from plagioclase, which, as before stated, has been pretty clearly proved in the case of the Norwegian rock, is not so evident in these similar rocks from Canada. There is certainly nothing in the sections fatal to this supposition, and several facts mentioned in this description of the slides seem to give some support to it. A much more exhaustive study of the rocks in their relations to the pyroxenic and dioritic rocks of the district would, however, be required to decide the question, and such an investigation would probably throw additional light on the curious paramorphism which the constituents of some rocks undergo, apparently under changed conditions of pressure. Fouqué's experiment, referred to above, on the minerals resulting from prism of the Norwegian rock, is of especial interest in this connection, as tending to show that hornblende and scapolite are not stable forms at high temperatures, at least under the ordinary pressure. The whole question is one of much interest, and one which, of late, has attracted a good deal of attention.[1]

As mentioned above, the rocks from McDougall and Palmerstone occur associated with crystalline limestones

[1] See Williams on The Gabbros and Associated Hornblende Rocks occurring in the neighbourhood of Baltimore, Md., p. 49. Bull. U. S. Geological Survey, No. 28.

of the Laurentian System. There are, however, many amphibolites and dioritic rocks occurring in the same district intimately associated with these limestones, but which contain no scapolite whatever. There is, for example, a great thickness of amphibolites, interstratified with crystalline limestone, exposed on the north shore of the Ottawa, just below the town of Arnprior, which we examined some years ago when on a visit to that locality for the purpose of endeavouring to discover the Scapolite-Diorite in place. They are all rather fine-grained and weather dark gray and black, and have a more or less distinct foliation. They were followed for a distance of about five miles below Arnprior, being gradually replaced by quartz feldspar rocks. Like all the other amphibolites and dioritic rocks of the district which do not hold scapolite, when examined with the naked eye the feldspar is seen to be wanting in that peculiar bluish-white tint characteristic of the scapolite, and which the Norwegian geologists compared to wet snow. Three specimens, collected respectively a quarter of a mile, two and a quarter, and three and a half miles below Arnprior, were sliced and examined. The last of these is traversed by little pegmatite veins, and under the microscope is found to be composed of hornblende, biotite and plagioclase, with accessories of epidote and sphene. The hornblende is green in colour, strongly pleochroic and without any tendency to a fibrous structure. It occurs in irregular shaped fragments, which occasionally have an imperfect idiomorphic development, and which mark the lines of foliation. The biotite, which is present in much smaller amount than the hornblende, is brown, with the usual strong dichroism and parallel extinction. The plagioclase is generally twinned, the lamellæ being narrow and the twinning generally faint. All untwinned grains which could be found cut in a direction at right angles to an optic axis, showed the revolving bar of a biaxial crystal. They polarize in rather dull tints, and extinguish simultaneously over the whole surface, showing little or no evidence of having been submitted to pressure.

The pyrite, epidote and sphene occur in small amount in little irregular shaped grains.

The other two specimens contain no biotite, but hold a certain amount of quartz, recognized by the absence of cleavage and decomposition products and by its uniaxial and positive character. The quartz grains are sometimes broken, but do not show much evidence of pressure either. The specimen collected about a quarter of a mile below Arnprior contains a considerable amount of quartz, while that from two and a quarter miles below, holds less quartz, and contains, in addition to the pyrite, a little magnetite or ilmenite.

To sum up, therefore, it may be said :—

(1) That the Scapolite Diorite, which in Norway occurs so intimately associated with the apatite deposits, does not occupy the same relation to the Canadian deposits.

(2) That its place in Canada is taken by certain pyroxenic rocks which have not, as yet, been thoroughly studied.

(3) That Scapolite Diorite and transition rocks between it and gabbro, identical with the Norwegian rocks, do occur in our Laurentian System, associated with amphibolites and crystalline limestones.

EOZOON CANADENSE.

By Sir J. WILLIAM DAWSON, F.R.S., etc.

[Extracts from a memoir by Sir William Dawson in the Publications of the Peter Redpath Museum, Sept., 1888.]

I. STATE OF PRESERVATION.

We may first ask, under this head, what are the structures supposed to be preserved. On the supposition that Eozoon was a marine organism, its test or hard part, which grew on the sea bottom, consisted of a series of calcareous laminæ, not perfectly parallel, but bending towards each other at intervals, and uniting so as to form flattened chambers, deeper toward the base and becoming shallower in the upper part, while at the top they sometimes become broken up into rounded cells or chamberlets, constituting an

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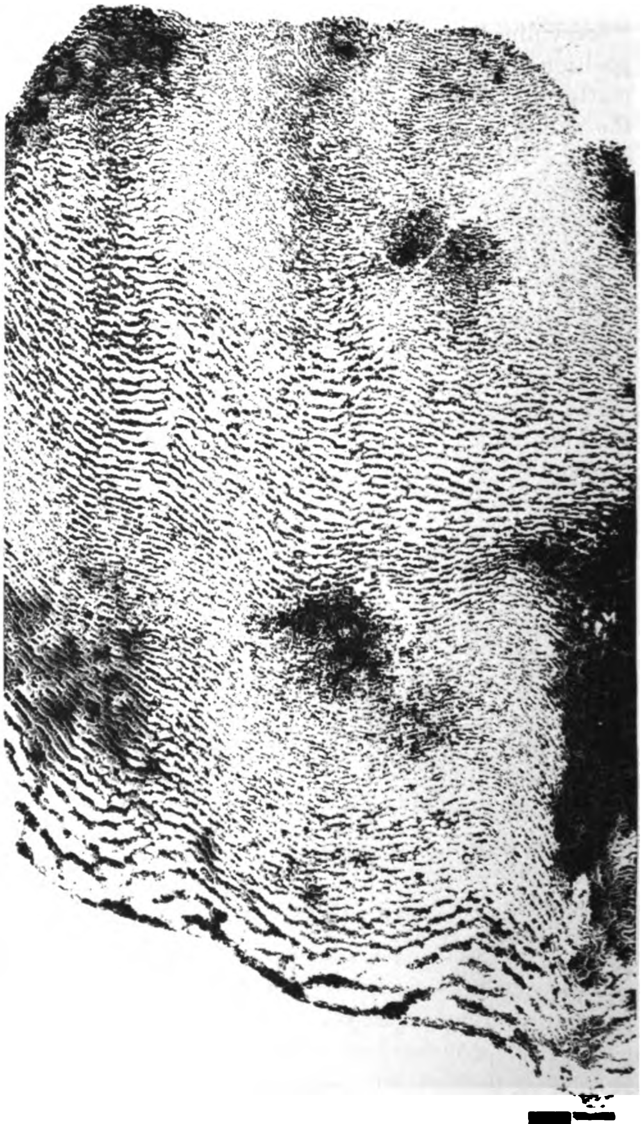

Fig. 2. Nature-printed specimen of Eozoon.

"acervuline" mass. The chambers, which, on the supposition above stated, were originally filled with the sarcodic matter of the animal, were after death and the burial of the skeleton in some calcareous sediment, occupied with mineral substances introduced by infiltration, and more especially with serpentine and pyroxene, which were at the same time being deposited in layers and concretions in the surrounding material. When well preserved, the calcareous laminæ are seen to be traversed with innumerable canals, terminating in very fine tubuli. These canals are occupied by serpentine, pyroxene or dolomite, or by limestone, according to the state of preservation. (See Figs. 2, 3, 4).

The masses of Eozoon sometimes consist of as many as one hundred and fifty laminæ superimposed. Originally flat or rounded, they assumed in growth club-shaped or turbinate forms, and sometimes by coalescence formed wide sheets or irregular masses, in which case they are often observed to be traversed in their thickness by conical or cylindrical tubes or oscula. The outer surface and the walls of these tubes were strengthened by bending and coalescence of the laminæ. The mode of growth would be similar to that of more modern organisms of the genera *Loftusia*, *Carpenteria* and *Polytrema*, and to that of some kinds of *Stromatoporæ*. Finally, these calcaceous tests were liable to be broken up and scattered in fragments over the sea bottom, constituting the material of beds of organic limestone, like the coral sand that surrounds modern reefs and islands.

Assuming Eozoon to be a fossil animal of the characters above described, its mode of preservation in the ordinary serpentinous specimens is more simple than that of many fossils of later date. The calcareous walls have remained substantially unchanged, except that they have become somewhat crystalline in structure, and in many cases have assumed the crystalline cleavage of calcite; but this change is quite common in Palæozoic shells and crinoids. The chambers have been filled and the canals and tubuli traversing the calcareous test have been

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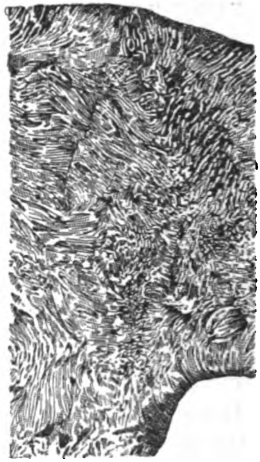

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Fig. 3. Coral System of Eozoon injected with serpentine (magnified).
Fig. 4. Very fine canals and tubuli filled with Dolomite (magnified).
(From Micro-photographs.)

injected with a hydrous silicate. This is a filling up by no means infrequent in later fossils, and as Dr. Carpenter has shewn, it is going on in the modern seas in the case of foraminifera and other porous tests and shells injected with glauconite. Numerous instances of this kind exist in Palæozoic limestones. Several of these are described in my paper on fossils mineralized by silicates (*Jour. Geol. Society*, Feb. 1879, *et infra*), and I have recently met with another interesting example in a limestone from the Lower Carboniferous of Maxville, Ohio, collected by Prof. E. B. Andrews. and presented to me by Dr. T. Sterry Hunt, in which many crinoids and corals are beautifully injected with a greenish hydrous silicate resembling glauconite.

Mineralization of this kind is in reality greatly less complex than that in which, as in many fossil corals and fossil woods, the calcarerous or woody matter has been entirely removed and replaced by silica, oxyde of iron or pyrite. In many cases also in Palæozoic fossils the cavities have been filled with successive coats of different minerals

giving very complex appearances. I have in my collection a specimen of Stigmaria in which every vessel has been coated in the interior with successive linings of red and white calcite, and subsequently filled with calcite and pyrite, and in a Sternbergia from the coal formation the phragmata are silicified and encrusted with crystalline silica and pyrite, while the interstices are filled in with sulphate of barium. Such complex and eccentric examples of fossilization are much more intricate than anything that occurs in the ordinary examples of Eozoon.

Geologists should also be reminded that porous fossils, once infiltrated with siliceous minerals, are practically indestructible. Nothing short of absolute fusion can wholly deface their structures, and these remain in many cases in the utmost perfection when the external forms have been wholly lost or inseparably united with the matrix.

There is therefore nothing anomalous in the preservation of Eozoon, except its occurrence in rocks highly crystalline and of unusually great age; and but for these circumstances it is probable that no doubt would have been entertained on the subject. The question of the crystalline structure of rocks containing fossils deserves, however, some further consideration.

That in limestones a crystalline condition is compatible with the preservation of fossils, and more especially with the preservation of their microscopic characters, is very well known. Many Palæozoic limestones are of a highly crystalline character, and yet retain abundant evidence of their organic origin. For example, the Chazy and Trenton limestones of the vicinity of Montreal have a perfectly crystalline fracture, and present to the naked eye no trace of any form but cleavage planes of calcite, yet, when sliced and studied with the microscope, they are seen to consist of organic fragments having their most minute structures preserved, but so completely enveloped and identified with the crystalline calcite which fills their pores and interstices that they cleave with it. It is to be observed also that in these limestones, instances occur in which organic fragments are

inscribed in hexagonal crystals and might be mistaken for mere crystals containing impurities, did not these latter show on examination the original structures. Mesozoic and even Tertiary limestones have sometimes assumed the same conditions. That the Laurentian limestones holding Eozoon have undergone no change incompatible with the preservation of fossils, is proved by the fact that they still retain their original lamination, and present layers, often quite thin, of dolomite and calcite, and of the latter with various mixtures of serpentine, graphite, &c. Now there is no reason why the structures of any fossil should not survive when the lamination of the limestone remains.

Another example quite in point is that of some large calcified trees of the coal period. When broken, these trunks show large coarse cleavable crystals like those of stalagmite, but when sliced it is often found that the structure has been perfectly preserved in the midst of the crystallization.

That the laminæ of Eozoon themselves are in some cases replaced by dolomite, or partially by flocculent serpentine, is no argument against their organic nature. Stromatoporæ, shells and corals are often found to have their calcareous material wholly or in part replaced by other minerals, as dolomite, carbonate of iron, pyrite and silica. The replacement by the latter mineral more especially gives us many of our most beautifully preserved Palæozoic fossils. At Pauquette's Rapid on the Ottawa, among the numerous fossils found in a silicified state imbedded in the limestone, are many Stromatoporæ, and in these the layers are not merely filled but actually replaced with silica, which, while it retains the form of the laminæ is itself arranged in curious concretionary grains which might at first sight be mistaken for a part of the structure.

In the Silurian dolomite of Guelph in Ontario, specimens of Cœnostroma, replaced by perfectly crystalline dolomite, not only show their lamination, but in some cases even their fine canals. In the gray dolomite of Niagara, similar appearances are observed. In some places it is filled with masses of Stromatopora dispersed through the dolomite just

as Eozoon is in the Laurentian limestone. These fossils are silicified and vary in diameter from a foot to an inch. The greater part are spheroidal in form, but some are cylindrical or club-shaped, while others spread into flat sheets or are of various irregular shapes. In many specimens, the structure is beautifully preserved; but in others it has partially disappeared, and the substance of the fossil is replaced by coarsely crystalline calcite or dolomite, or presents cavities lined with crystals of these minerals. There is reason to believe that many cavities in the limestone, now empty and coated with these crystals, were once occupied by Stromatoporæ, or by the species of sponge found in this limestone. In every respect, except in the absence of hydrous silicates, the mode of occurrence of these fossils resembles that of Eozoon at Côte St. Pierre.

In some such cases of replacement it is probable that the original material of the fossil was arragonite, and for this reason more easily removed or replaced. Every Palæontologist is familiar with the fact that arragonite or prismatic shell has been removed in cases where lamellar shell has remained, and the latter has sometimes disappeared when compact calcite shells, like those of Balanus, for example, have escaped. In the case of Eozoon, however, as in that of foraminifera in general, the calcite seems to have been of the less perishable kind, and this may be connected with the integrity of the calcareous wall in the better preserved specimens.*

By what appears to a palæontologist a strange perversion of reasoning, some of the opponents of the organic nature of Eozoon take the badly preserved specimens as typical, and suppose that these represent an original mineral condition, which in the better preserved specimens has only assumed its greatest perfection.

As I have often urged, this kind of argument would invalidate all reasoning from the structures of fossils. In all large masses of fossil coral or wood, we find portions in

* I have elsewhere remarked that the calcareous wall of Eozoon retains a *finely granular* texture, similar to that seen in shells, etc., in altered Palæozoic limestones.

all stages of disintegration. Sometimes the centre is a mere structureless mass, when the surface is perfectly preserved; Sometimes it is the surface that is disorganised. In other cases portions are well preserved, and others disintegrated in the most capricious manner. I have specimens of fossil coniferous wood in which portions are disintegrated along the medullary rays, giving the appearance of widely separated wedges, and others in which concentric bands are alternately preserved and destroyed, others in which irregular spaces have been eaten out and filled with structureless matter, and others in which crystalline or concretionary structures have been developed in spots, giving the most grotesque and inexplicable appearances. Yet in all these cases we have the general form of a trunk and portions of it in which the structures are preserved. In one example of silicified wood I have found regularly formed prisms of quartz deposited in rows along the woody fibres as if these had formed original parts of the structure. In fossil woods it is also very common to find the tissues compressed, folded and contorted in spots, so as to give the most unnatural possible appearances. Now in all such cases it is surely reasonable to take the well-preserved portion as the means of interpreting the rest, though I have known cases where, for want of attention to this, portions of woody tissue have been described as cellular, in consequence of their being disintegrated by the crystallization of quartz.

It is also to be observed that there is a gradation in the probability of the preservation of structures. A very finely tubulated structure, like that which is supposed to have constituted the proper wall of Eozoon, is rarely perfectly preserved. In modern foraminifera infiltrated with glauconite, we usually see their finer structures preserved only in spots, or a part of the length of the tubes only filled. The larger cells are often infiltrated when the tubuli are empty. A coarse canal system is more likely to be perfectly infiltrated. Further, in Tertiary Nummulites the fine tubes are often filled with calcite, while the

glauconite has penetrated the coarser portions only. This is very well seen in the beautiful specimens from Kempfen in Bavaria. All this applies to Eozoon. The most difficult part to find is its proper wall. The coarser canals are often present without the finer. The coarser parts of the canals are sometimes filled with serpentine, when the finer branches are filled with calcite or dolomite. The cells and laminæ are sometimes quite manifest when the finer structures are absent. All this is in perfect harmony with the analogy of other fossils.

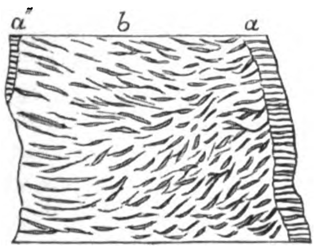

Fig. 5. Slice of single lamina of Eozoon, magnified. (*a*) Tubulated wall; (*b*) Canal system; both injected with Serpentine.

Eozoon also agrees with other fossils in the independence of its form with reference to the mineral matter with which the cavities may be filled. This peculiarity commended itself to the sagacity of Sir William Logan, and induced him to argue for the organic nature of Eozoon before its minute structures were known, and since these were investigated the argument has been much strengthened. The minerals serpentine, pyroxene and loganite are found filling the chambers, and the two former with dolomite and calcite occupy the canals, which often present calcareous fillings in the finer ramifications, when the main stems are occupied with serpentine. These facts are readily explained if we assume cavities and tubes of definite form to be filled with minerals according to circumstances; but they are not explicable on the supposition of a merely inorganic origin. They correspond perfectly with facts observed in the infiltration and replacement of all classes of fossils, which often

occur in such a way that similar spaces are occupied in one part of the fossil with one mineral, in others with another.

In connection with this, the imperfections in the preservation of Eozoon are also parallel with those observed

Fig. 6. Cross section of canals, injected with serpentine, highly magnified.

in different organic substances. As an example, I have already mentioned that in some of the specimens a white flocculent serpentine encroaches upon the calcareous walls or in part replaces them. This would indicate the partial removal of the calcite prior to or at the same time with the filling. In some cases also the calcite wall is wholly or in part replaced with dolomite. Such changes are not infrequent in Palæozoic fossils in which the substance of a calcareous part has often been wholly removed and replaced by another mineral or has been partially eroded and so in part replaced.

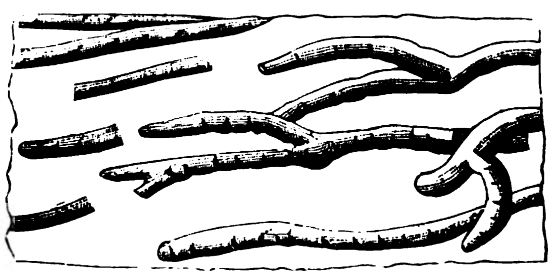

Fig. 7. Longitudinal section of canals, highly magnified.

There are other peculiarities deserving special notice :—

1. In some specimens the serpentine filling the chambers presents a laminated appearance, as if deposited in successive layers. There even occur serpentine-lined cavities and canals with calcareous filling. This may depend on the deposition of serpentine in coatings on the sides of those cavities, leaving perhaps a central portion to be filled with calcite, or may in some cases be the result of the filling of the cavities with successive laminæ of serpentine from below upward. In either case we have frequent examples of these varieties of filling in ordinary fossils.

2. There are examples of Eozoon in which no serpentine or other mineral filling appears, and in which the whole mass is calcareous, though presenting canals filled with serpentine or dolomite. In these cases the explanation is that the mass of Eozoon has not had its cavities filled, but has been compressed by pressure into a solid mass. Such a state of preservation is often observed in other fossils, more especially in fossil wood, in which the cell-walls often become under pressure wholly coalescent.

3. The condition of the proper wall also illustrates the manner of preservation. The tubes which compose it are so extremely fine that they are rarely injected with silicates. Sometimes they are merely occupied with calcite, and in this case the wall constitutes an apparently structureless band, or merely presents a band of slightly different appearance from the remainder. Sometimes the tubuli appear as fine continuations of the canals; or as a more or less perfect fringe of fine lines, and in decalcified specimens, this part is often represented merely by a tabular space between the ends of the canals and the serpentine filling. In the best specimens and in very thin slices under a high power, these tubuli appear as hollow threads with expanded terminations, but this is rarely to be seen. All these conditions may be equally well observed in Nummulites injected with glauconite.

4. The larger masses of Eozoon have often suffered considerable contortion and even faulting, and this seems to have occurred in some instances previous to complete fossilization. This is a condition often observed in fossils of all

ages, and every palæontologist is familiar with the fact that in all the older formations even the hardest calcareous fossils have been affected with accidents of this nature.

There are even a few examples in the collections which would seem to indicate that portions had been broken off, perhaps by the action of the waves, previous to fossilization. It is not unlikely that some of the specimens have been loose and subject to the action of the waves and currents before being imbedded.

5. An interesting feature in connection with the specimens of Eozoon from St. Pierre, noticed in previous papers, is the occurrence of layers filled with little globose casts of chamberlets, single or attached in groups, and often exactly resembling the casts of Globigerinæ in greensand. On weathered surfaces they were often especially striking when examined with the lens. In some cases, the chamberlets seem to have been merely lined with serpentine, so that they weather into hollow shells. The walls of these chamberlets have had the same tubulated structure as Eozoon;

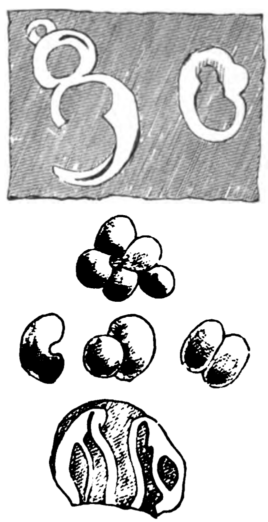

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Fig. 8. Sections and casts of detached chamberlets, magnified.

so that they are in their essential characters minute acervuline specimens of that species, and similar to those I described in my paper of 1867 as occurring in the limestones of Long Lake and Wentworth, and also in the Loganite filling the chambers of specimens of Eozoon from Burgess. Some of them are connected with each other by necks or processes, in the manner of the groups of chamberlets described by Gümbel as occurring in a limestone from Finland, examined by him. That they are organic I cannot doubt, and also that they have been distributed by currents over the surface of the layers along with fragments of Eozoon. Whether

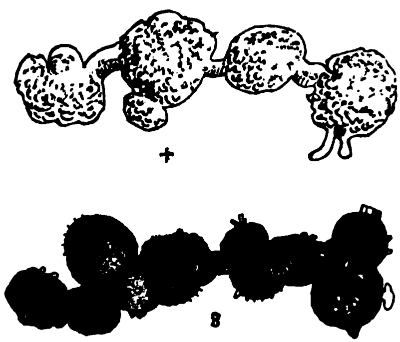

Fig. 9. Groups of chamberlets, Canada and Finland, magnified.

they are connected with that fossil or are specifically distinct, may admit of more doubt. They may be merely minute portions detached from the acervuline surface of Eozoon, and possibly of the nature of reproductive buds. On the other hand they may be distinct organisms growing in the manner of Globigerina. As this is at present uncertain, and as it is convenient to have some name for them, I have proposed to term them Archæosphærinæ, understanding by that name minute Foraminiferal organisms, having the form and mode of aggregation of Globigerina, but with the proper wall of Eozoon.

A specimen in the colleetions from Cote St. Pierre deserves notice (Fig. 11 *infra*) as illustrating the nature

of Archæosphærinæ. It is a small or young specimen, of a flattened oval form, 2½ inches in its greatest diameter and of no great thickness. It is a perfect cast in serpentine, and completely weathered out of the matrix, except a small portion of the upper surface, which was covered with limestone which I have carefully removed with a dilute acid. The serpentinous casts of the chambers are in the lower part regularly laminated; but they are remarkable for their finely mammilated appearance, arising from their division into innumerable connected chamberlets resembling those of Archæosphærinæ. In the upper part the structure becomes acervuline, and the chamberlets rise into irregular prominences, which in the recent state must have been extremely friable, and, if broken up and scattered over the surfaces of the beds, would not be distinguishable from the ordinary Archæosphærinæ. This specimen thus gives further probability to the view that the Archæosphærinæ may be for the most part detached chamberlets of Eozoon, perhaps dispersed in a living state and capable of acting as germs. Other specimens weathered out and showing granular forms have been collected by Mr. E. H. Hamilton and are now in the Museum.

6. Specimens of Eozoon have been traversed by veins of chrysotile and calcite which cross all their structures indifferently, and often seriously affect their preservation. But similar accidents have affected fossils of every age, and especially those of the older and more altered rocks. The

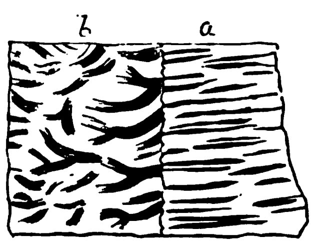

Fig. 10. Chrysotile vein crossing Eozoon, magnified. (*a*) Vein of fibrous Serpentine or Chrysotile; (*b*) Tubulation of Eozoon.

manner in which these veins cross the forms of Eozoon in truth present an additional proof that these are original enclosures in the limestone, and not products of any subsequent change.

7. In connection with this I would refer to a fact which I have often previously mentioned, namely, that the Laurentian limestones, when destitute of the laminated forms characteristic of Eozoon, are nevertheless often filled with small patches showing the minute structures. These I regard as fragments of Eozoon broken up and scattered by the currents. In this case, the remainder of these bands of limestone must be composed of fragments of other organisms which not being porous have not been so preserved by infiltration as to be distinguishable. In the original investigation of Eozoon, however, a great number of slices of these fragmental limestones were prepared by Mr. Weston the lapidary of the Geological Survey, and carefully examined, and though they showed no distinct structure except that of Eozoon, I felt convinced, and expressed this conviction in my original description, that these fragments presented such traces of structure as one is familiar with in metamorphosed organic limestones of more modern date.* At Côte St. Pierre there are several layers of limestone and dolomite studded with this fragmental Eozoon, and in specimens from Brazil, from Warren County, New York, and from Chelmsford in Massachusetts, and St. John, New Brunswick, the traces of Eozoon which I have observed consist of these fragments.

8. In slicing one of my specimens from Côte St. Pierre, I have recently observed a very interesting peculiarity of structure, which deserves mention. It is an abnormal thickening of the calcareous wall in patches extending across the thickness of four or five lamellæ, the latter becoming slightly bent in approaching the thickened portion. This thickened portion is traversed by regularly placed parallel canals of large size, filled with dolomite, while the intervening calcite presents a very fine dendritic tubulation. The longitudinal axes of the canals lie nearly in the plane of the ad-

* Especially the finely granular structure above referred to.

jacent laminæ. This structure reminds an observer of the *Cœnostroma* type of *Stromatopora*, and may be either an abnormal growth of Eozoon, consequent on some injury, or a parasitic mass of some stromatoporoid organism finally overgrown by the Eozoon. The structure of the dolomite shows that it first incrusted the interior of the canals, and subsequently filled them—an appearance which I have also observed in some of the larger canals filled with serpentine, and which is very instructive as to their true nature.

The above statements have reference to state of preservation, and are intended to remove misconceptions on that subject, but the mere fact of so many coincidences both in state of preservation and defects and imperfections between Eozoon and ordinary fossils, furnishes in itself, independently of other evidence, no small proof of its organic origin.

II. NEW FACTS AND SPECIAL POINTS.

Under this heading, I shall summarize some of the previous statements, and add some special facts bearing on the character of the specimens and their interpretation.*

(1.) *Form of Eozoön Canadense.*

Hitherto this has been regarded as altogether indefinite, and it is true that the specimens are often in great confluent masses or sheets, the latter sometimes distorted by the lateral pressure which the limestone has experienced. The specimen from Tudor, however, figured by Sir W. E. Logan in the *Quarterly Journal* of the Geological Society, 1867, p. 253, and that described by me in the "Proceedings of the American Association" in 1876, and figured in my work, "Life's Dawn on Earth," gave the idea of a turbinate form more or less broad. More recently additional specimens weathered out of the limestone of Côte St. Pierre have been

* Nos. 1 to 11 were read at the Meeting of the British Association, Sept. 5, 1887, and printed in part in *Geological Magazine*, February, 1888.

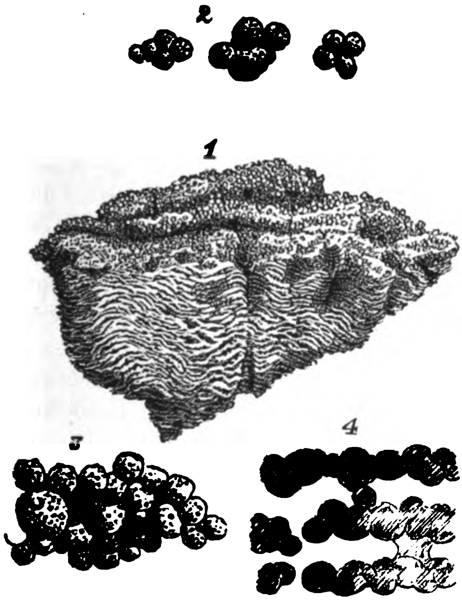

Fig. 11. *Eozoon Canadense.* (1) Small specimen disengaged by weathering. (2) Acervuline cells of upper part—magnified. (3) Tuberculated surface of lamina—mag. (4) Laminæ of Serpentine in section, representing casts of the sarcode—mag.

obtained by Mr. E. H. Hamilton, who collected for me at that place; and these, on comparison with several less perfect specimens in our collections, have established the fact that the normal shape of young and isolated specimens of *Eozoön Canadense* is a broadly-turbinate, funnel-shaped, or top-shaped form, sometimes with a depression on the upper surface giving it the appearance of the ordinary cup-shaped Mediterranean sponges. (Fig. 11.) These specimens also show that there is no theca or outer coat either above or below, and that the laminæ pass outwards without change to the margin of the form, where, however, they tend to coalesce by subdividing and bending together. The laminæ are thickest at the base of the inverted cone, and become thinner and closer on ascending, and at the top they

become confounded in a general vesicular or acervuline layer. I feel now convinced that broken fragments of this upper surface scattered over the sea-bottom formed those layers of *Archæosphærinæ* which at one time I regarded as distinct organisms.

It is to be observed, however, that other forms of Eozoön occur. More especially there are rounded or dome-shaped masses, that seem to have grown on ridges or protuberances, now usually represented by nuclei of pyroxene.

(2.) *Osculiform tubes.*

In the large number of specimens of Eozoön which have been cut or sliced in various directions, and are now in our museum at Montreal, it has become apparent that there are more or less cylindrical depressions or tubes, sometimes filled with serpentine and sometimes with inorganic calcite, crossing the laminæ at right angles. These seem to occur chiefly in the large and confluent masses, and are without any regular or definite arrangement. In some of the narrower openings of this kind the laminæ can be observed to subdivide and become confluent on the sides of these tubes, in the same manner as at the external surface. This circumstance induces me to believe that these are not accidental, but original parts of the structure, and intended to admit water into the lower parts of the masses. (See Frontispiece.) A central canal of a similar kind is well shown in the accompanying illustration.

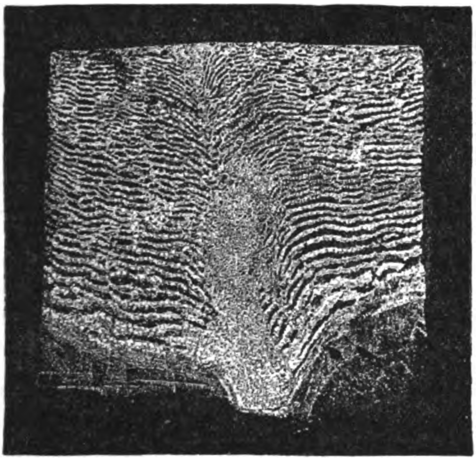

Fig. 12. Section of the base of a specimen of *Eozoon*. This specimen shows an osculiform, cylindrical perforation, cut in such a manner as to show its *reticulated wall* and the descent of the laminæ toward it. Two-thirds of natural size. From a photograph. Coll. Carpenter, also in Redpath Museum.

[This illustration (from Prof. Prestwich's "Geology," vol. ii., p. 21) has been courteously lent by the Clarendon Press, Oxford.]

(3.) *Beds of Fragmental Eozoön.*

If Eozoön was an organism growing on the sea-bottom, it would be inevitable that it would be likely to be broken up, and in this condition to constitute a calcareous sand or gravel. I have already in previous pages noticed Laurentian limestones containing such fragments, from the Grenville band at Côte St. Pierre, from the Adirondack Mountains in New York State, from Chelmsford, Massachusetts, and from St. John, New Brunswick, as well as from Brazil and the Swiss Alps. Indeed, the Laurentian limestones of most parts of the world hold fragmental Eozoön. In the Peter Redpath Museum are some large slabs of Laurentian limestone sawn under the direction of Sir W. E. Logan, and showing irregular layers and detached masses of Eozoön with layers or bands of limestone and of ophiolite. These are evidently layers successively deposited,

though somewhat distorted by subsequent movements. On selecting specimens from the white and more purely calcareous layers, I was pleased to find that they abound in fragments of laminæ of Eozoön, having the canals filled either with dolomite or with colourless serpentine. Other portions of the limestone show the peculiar granulated structure characteristic of the calcareous laminæ of Eozoön, but without any appearance of canals, which may in this case be occupied with calcite, not distinguishable from the substance of the laminæ. There are also indications in these beds of limestones of the presence of Eozoön not infiltrated with serpentine, but having its laminæ either compressed together, or with the spaces between them filled with calcite. There are other fragments which, from their minute structure, I believe to be organic, but which are apparently different from Eozoön.

(4.) *Veins of Chrysotile.*

I have in previous pages noticed the fact that the veins of fibrous chrysotile which abound in serpentinous limestones of the Laurentian are of secondary aqueous origin, as they fill cracks or fissures not merely crossing the beds of the limestone, but passing through the masses of Eozoön and the serpentinous concretions which occur in the beds. They must, therefore, have been formed by aqueous action long after the deposition, and in some cases after the folding and crumpling of the beds. In this respect they differ entirely from the laminæ of Eozoön, which have been subject to the same compression and folding with the beds themselves.

The chrysotile veins have, of course, no connection with the structures of Eozoön, though they have often been mistaken for its more finely tubulated portion. With respect to this latter, I believe that some wrong impressions have been created by defining it too rigorously as a "proper wall." In so far as I can ascertain, it consisted of finely divided tubes similar to those of the canal system, and

composed of its finer subdivisions placed close together, so as to become approximately parallel. (See Fig. 4 above.)

(5.) *Nodules of Serpentine.*

Reference has been made in previous papers to the nodules and grains of serpentine found in the Eozoön limestone, but destitute of any structure. These nodules, as exhibited in the large slabs already referred to, have however often patches of Eozoön attached to or imbedded in them, and they appear to indicate a superabundance of this siliceous material accumulating by concretionary action around or attached to any foreign body, just as occurs with the flints in chalk. The layers and grains of serpentine parallel to the bedding appear to be of similar origin.

(6.) *State of Preservation.*

Recent observations more and more indicate the importance and frequency of dolomite as a filling of the canals, and also the fact that the serpentine deposited in and around the specimens of Eozoon is of various qualities. Dr. Sterry Hunt has shown that the purely aqueous serpentine found in the Laurentian limestones is of different composition from that occurring with igneous rocks, or as a product of the hydration of olivine. There are, however, different varieties even of this aqueous serpentine, ranging in colour from deep green to white; and one of the lighter varieties has the property of weathering to a rusty colour, owing to the oxidation of its iron. These different varieties of serpentine will, it is hoped, soon be analysed, so as to ascertain their precise composition. The mineral pyroxene, of the white or colourless variety, is a frequent associate of Eozoon, occurring often in the lower layers and filling some of the canals. Sometimes the calcareous laminæ themselves are partially replaced by a flocculent serpentine, or by pyroxenic grains imbedded in calcite.

(7.) *Other Laurentian Organisms.*

In a collection recently acquired by the Peter Redpath Museum, from the Laurentian of the Ottawa district, are some remarkable cylindrical or elongated conical bodies, from one to two inches in diameter, which seem to have occurred in connection with beds or nodules of apatite. They are composed of an outer thick cylinder of granular, dark-coloured pyroxene, with a core or nucleus of white felspar; and they show no structure, except that the outer cylinder is sometimes marked with radiating rusty bands, indicating the decay of radiating plates of pyrite. They may possibly have been organisms of the nature of *Archæocyathus*; but such reference must be merely conjectural.

(8.) *Cryptozoum.*

The discovery by Prof. Hall, in the Potsdam formation of New York, and by Prof. Winchell in that of Minnesota, of the large laminated forms which have been described under the above name, has some interest in connection with Eozoon. I have found fragments of these bodies in conglomerates of the Quebec group, associated with Middle Cambrian fossils; and, whatever their zoological relations, it is evident that they occur in the Cambrian rocks under the same conditions as Eozoon in the Laurentian. I find also in the Laurentian limestones certain laminated forms usually referred to Eozoon, but which have thin continuous laminæ, with spongy porous matter intervening, in the manner of *Cyptozoum* or of *Loftusia.* Whether these are merely Eozoon in a peculiar state of preservation or a distinct structure, I cannot at present determine.

(9.) *Continuity and Character of containing Deposits.*

At a time when so many extravagant statements are made, more especially by some German petrologists, respecting the older crystalline rocks, it may be proper to state that all my recent investigations of the part of system

which I have called Middle Laurentian, especially in the district east of the Ottawa, vindicate the results of the late Sir William Logan as to the continuity of the great limestones, their regular interstratification with the gneisses, quartzose gneisses, quartzites, and micaceous schists, and their association with bedded deposits of magnetite and graphite, and also the regularity and distinctly stratified character of all these rocks. Farther, I regard the Upper Laurentian, independently of the great masses of Labradorite rock, which may be intrusive, as an important aqueous formation, characterised by peculiar rocks, more especially the anorthite gneisses. I am also of opinion that some of the crystalline rocks of the country west of Lake Superior are stratigraphically, and to a great extent lithologically, equivalent to the Upper Laurentian of St. Jerome and other places in the Province of Quebec, differing chiefly in the greater or less abundance of intrusive igneous rocks.

(10.) *Imitative Forms.*

The extraordinary mistakes made by some lithologists in studying imperfect examples of Eozoon and rocks supposed to resemble it, and which have gained a large amount of currency, have rendered necessary the collection and study of a variety of laminated rocks, and considerable collections of these have been made for the Peter Redpath Museum. They include banded varieties of dolerite and diorite, of gneiss, of apatite and of tourmaline with quartz, laminated limestone with serpentine, graphic granites, and a variety of other laminated and banded materials, which only require comparison with the genuine specimens to show their distinctness, but many of which have nevertheless been collected as specimens of Eozoon. I do not propose to enter into any detailed description of these here, but may hope, with the aid of Dr. Harrington, to notice them in forthcoming Memoirs of Peter Redpath Museum.

It is easy for inexperienced observers to mistake laminated concretions and laminated rocks either for *Stromatopora*

or for *Eozoon*, and such misapprehensions are not of infrequent occurrence. As to concretions, it is only necessary to say that these, when they show concentric layers, are deficient altogether in the primary requirements of laminæ and interspaces; and under the microscope their structures are either merely fragmental, as in ordinary argillaceous and calcareous concretions, or they have radiating crystalline fibres like oolitic grains. Laminated rocks, on the other hand, present alternate layers of different mineral substances, but are destitute of minute structures, and are either parallel to the bedding or to the planes of dykes and igneous masses. In the Montreal mountain there are beautiful examples of a banded dolerite in alternate layers of black pyroxene and white felspar. These occur at the junction of the dolerite with the Silurian limestone through which it has been erupted. Laminated gneissose beds also abound in the Laurentian. Still more remarkable examples are afforded by altered rocks having thin calcite bands, whether arising from deposition or from vein-segregation. One of these now before me is a specimen from the collection of Dr. Newberry, and obtained at Gouverneur, St. Lawrence County, New York. It presents thick bands of a peculiar granitoid rock containing highly crystalline felspar and mica with grains of serpentine; these bands are almost a quarter of an inch in thickness, and are separated by interrupted parallel bands of calcite much thinner than the others. The whole resembles a magnified specimen of *Eozoon*, except in the absence of the connecting chamber-walls and of the characteristic structures. A similar rock has been obtained by Mr. Vennor on the Gatineau; but it is less coarse in texture though equally crystalline, and appears to contain hornblende and pyroxene. These are both Laurentian, and I consider it not impossible that they may have been organic; but they lack the evidence of minute structure, and differ in important details from *Eozoon*. Another specimen from the Horseshoe Mountain in the Western States (I regret that I have mislaid the name of the gentleman to whom I am indebted for this

specimen) is a limestone with perfectly regular and uniform layers of minute rhombohedral crystals of dolomite. The layers vary in distance regularly in the thickness of the specimen from two millimetres to one, and must have resulted from the alternate deposition in a very regular manner of dolomite and limestone. These are but a few of the examples of imitative structures which might readily be confounded with *Eozoon*, or which, if resulting from organic growth, have lost all decisive evidence of the fact.

Perhaps still more puzzling imitative forms are those referred to by Hahn, which occur in some felspars, and which I have found in great beauty in certain crystals of orthoclase from Vermont. They are ramifying tubes resembling the canal-system of *Eozoon*, and are evidently a peculiar form of gas-cavities or inclusions. Similar appearances are, however, often presented by the more minute and microscopic varieties of graphic granite, in which the little plates might readily be mistaken, in certain sections, for organic tubulation.

In the present state of knowledge, it is perhaps more excusable to mistake such things for organic structures than to deny the existence of true organic structures because they resemble such forms. Those who have examined moss-agates are familiar with the fact that while some show merely crystals of peroxide of iron or oxide of manganese, others present the forms of *Vaucheriæ* or *Confervæ*. So if one were to place side by side some fibres of asbestos, spicules of *Tethea*, and coniferous wood, preserved, like some from Colorado, as separate white siliceous fibres, they might appear alike; but, even if thoroughly mixed together, the microscope should be able easily to distinguish them. I have specimens of fossil wood, collected by Hartt in Brazil, which have been mineralized by limonite in such a manner that no one, without microscopic examination, could believe them to be other than fibrous brown hæmatite. Such difficulties the micro-geologist must expect to find, and by patient observation to overcome.

(11.) *Alternation of Mineral Layers.*

It has been suggested by Mr. Julien* and others that Eozoönal structure may be due to the alternation of mineral layers formed in the passage-beds between concretions and other mineral masses, and their enclosing matrix. The objections to this view are:

1. Laminated passage-rocks and laminated concretionary forms have only simple laminæ, whereas *Eozoon* has connected or reticulating laminæ.

2. Laminated passage-rocks have no structure other than crystalline. *Eozoon* has beautiful tubulation in its calcareous walls, besides large tubes or oscula.

3. Sometimes (not usually) pyroxene is the siliceous part of *Eozoon;* or, as we hold, the mineralizing agent. More usually it is serpentine, sometimes loganite, or dolomite, or mere earthy limestone. It is not possible that all these minerals should assume the same forms.

4. Pyroxene and serpentine both occur in nodules and bands in the Laurentian limestones, and in most cases without any traces of *Eozoon*, while *Eozoon* occurs in the limestone remote from such nodules and bands, where no passage of any kind can occur, and presents distinct forms.

5. There are only two localities known to me, one in a quarry near Côte St. Pierre, and one at Burgess, where a bed with badly preserved *Eozoon* occurs in a manner which would even suggest such an idea. Pyroxene is present in the one case, and loganite in the other.

6. I have often thought of this suggested explanation, and have compared *Eozoon* with all sorts of banded and passage-rocks taken from the Laurentian and other formations, but have seen no reason to adopt such a view for *Eozoon*. I have accumulated in the Peter Redpath Museum at Montreal as above stated, a very large number of laminated and passage-rocks and concretions for purposes of comparison.

7. How on such an hypothesis can we explain the beds of limestone composed of or filled with fragments of *Eozoon*?

* Proceed. Amer. Assoc. vol. xxxiii. 1884, pp. 415, 416.

"RINGED TREES."

BY W. L. GOODWIN, QUEEN'S UNIVERSITY, KINGSTON.

It is usually the case that a tree from which a complete ring of bark has been removed, dies within a year. Botanists teach that the continuity of the cambium layer at any part is essential to the life of all parts above. When the bark is removed, the cambium layer is torn asunder, and the part adhering to the tree as a slimy layer soon dries and decays. The tree may survive during the rest of the summer, but puts forth no leaves the next spring. In fact, I believe "ringed" trees *usually* survive the operation for some months, but on this point I should like to hear the testimony of those who have had experience of destroying trees in this way. It is a pretty well established fact that the circulation of the nutritive juices of a tree takes place mostly through the cambium, but that there are other channels for the sap is proved by the existence of the tree after it has been ringed. However, these subsidiary channels are evidently not sufficient to sustain life in the tree for more than a very limited period. As far as I know, only one exception to this rule has been recorded. A tree in the Botanical Gardens of Paris survived the operation for several years. I have to bring before the readers of the *Record of Science* another case which first came under my observation five years ago (the summer of 1883). It is a common pine tree, which had been ringed several years before I saw it—just how many, I could not ascertain. The tree stands at the edge of the pine woods of Studley, Halifax, Nova Scotia, and is one of two rising from a common trunk which bifurcates immediately above the surface of the soil. The trees are about twenty-two feet high, and begin to branch freely at about six feet from the ground. The ring is about four feet from the fork and is eight inches broad. The exposed wood is dead, and no signs of life appear within half an inch of the surface. Within that the wood seems to be living. That the tree has grown considerably since it was ringed is shown by the following measurements, made this summer:—

Circumference below ring	.................19½	inches.
" above "	26	"

The diameter of the tree has thus become two inches greater above than it is below the ring. The condition of the bark and cambium layer below the wound shows that the surface of the tree has died for a considerable distance (over six inches.) Above the wound, the bark and cambium are living and seem to have pushed down over the scar about half an inch. The same process had been evidently begun below the ring before the death of the cambium layer.

From measurements made five years ago, I should judge that the tree must have been ringed at least ten years before that date, so that this tree has survived its injury probably fifteen years. Unfortunately the notes of the first measurement are not at hand for comparison. At that date the ringed tree seemed almost as thrifty as its companion, but the foliage showed some signs of imperfect nutrition. At present, the tree is in much poorer condition, many of the branches being dead and the foliage scanty on those that are living.

The problem is: How has the tree been nourished since it was ringed? Is it a case like that often occurring in surgical cases and depending on the anastomosis of arteries? Is it possible that the subsidiary channels of communication between the earth and the branches enlarged to meet the emergency for a time, but not sufficiently to allow the tree to live out its life.

Studley, Halifax, Sept. 1, 1888.

[It is well known that the general nutrition of a tree is dependent upon the movement of fluids upward from the soil through the sap wood, in which the process of lignification has been developed in only a slight degree; while the formation of the new structure proceeds from tissues nourished by fluids contained in the living bark, and having a general downward direction of movement. In cases of girdling, the conductive sap wood becomes exposed to the atmosphere and dessication proceeds radially inward, while

there is a simultaneous lignification of the same tissues radially outward. Both causes operate to destroy the conductive power, and, under ordinary circumstances, it therefore only becomes a question of time how long the tree will live. Generally a tree will put forth its leaves the second year, but die before the season is over.

Under very favorable conditions of growth, the girdle may be bridged over in season to save the tree. One case of this kind was brought under the notice of the present writer a few years ago, in which a willow tree had been girdled by mice for a distance of over a foot. Yet during the growth of the spring immediately following, new structure was pushed out from above in such a way as to form a bridge, which later united to the trnnk, and also several roots which struck the soil and established independent connection between it and the upper part of the tree. Similar reparation is known to have occurred in other cases, but it is usually found that the favorable conditions are great vitality and the presence of an excess of moisture.

The case cited above is an interesting and peculiar one. It is not susceptible of explanation upon the theory of anastormosing vessels. It may possibly be accounted for upon the ground that the outer layers of wood in becoming hard, dry and filled with air, thereby established a protective layer which prevented, or at least retarded, further change in that direction; while the necessarily reduced vital condition of the tree may have greatly retarded the ordinary lignifaction of the cells to such an extent as to render the continued passage of fluids, and thus a very slow rate of growth in the tree as a whole, possible. In such case, the final death of the tree could only be a question of time. and from the facts stated, it would appear that at the time of the last observation its end must have been near.—Ed.]

On the Eozoic and Palæozoic Rocks of the Atlantic Coast of Canada in Comparison with those of Western Europe and the Interior of America.*

By Sir J. W. Dawson, LL.D., F.R.S., F.G.S.

(*Abstract.*)

The author referred to the fact that since 1845 he had contributed to the Proceedings of the Geological Society a number of papers on the geology of the eastern maritime provinces of Canada, and it seemed useful now to sum up the geology of the older formations, and make such corrections and comparisons as seemed warranted by the new facts obtained by himself and by other observers of whom mention is made in the paper.

With reference to the Laurentian, he maintained its claim to be regarded as a regularly stratified system, probably divisible into two or three series, and characterized in its middle or upper portion by the accumulation of organic limestone, carbonaceous beds, and iron ores on a vast scale. He also mentioned the almost universal prevalence in the northern hemisphere of the great plications of the crust which terminated this period, and which necessarily separate it from all succeeding deposits. He next detailed its special development on the coast of the Atlantic, and the similarity of this with that found in Great Britain and elsewhere in the west of Europe.

The Huronian he defined as a literal series of deposits skirting the shores of the old Laurentian uplifts, and referred to some rocks which may be regarded as more oceanic equivalents. Its characters in Newfoundland, Cape Breton, and New Brunswick were referred to, and compared with the Pebidian, &c., in England. The questions as to an Upper Member of the Huronian or an intermediate series, the Basal Cambrian of Matthew in New Brunswick, were discussed.

* Proc. Geolog. Soc., London.

The very complete series of Cambrian rocks now recognized on the coast-region of Canada was noticed, in connection with its equivalency in details to the Cambrian of Britain and Scandinavia, and the peculiar geographical conditions implied in the absence of the Lower Cambrian over a large area of interior America.

In the Ordovician age a marginal and submarginal area existed on the east coast of America. The former is represented largely by bedded igneous rocks, the latter by the remarkable series named by Logan the Quebec Group, which was noticed in detail in connection with its equivalents further west, and also in Europe.

The Silurian, Devonian, and Carboniferous were then treated of, and detailed evidence shown as to their conformity to the types of Western Europe rather than to those of America.

In conclusion, it was pointed out that though the great systems of formations can be recognized throughout the Northern Hemisphere, their divisions must differ in the maritime and inland regions, and that hard and fast lines should not be drawn at the confines of systems, nor widely different formations of the same age reduced to an arbitrary uniformity of classification not sanctioned by nature. It was also inferred that the evidence pointed to a permanent continuance of the Atlantic basin, though with great changes of its boundaries, and to a remarkable parallelism of the formations deposited on its eastern and western sides.

THE ST. LAWRENCE BASIN AND THE GREAT LAKES.*

J. W. SPENCER.

(Abstract.)

ESTABLISHMENT AND DISMEMBERMENT OF LAKE WARREN.

This is the first chapter in the history of the great lakes and is subsequent to the deposit of the upper boulder clay, and therefore the lakes are all very new in point of geological line. By the movements of warping of the earth's crust, as shown in the beaches—after the deposit of the later boulder clay—the lake region was reduced to sea level and there were no Canadian highlands northward of the great lakes. Upon the subsequent elevations of the continent beaches were made around the rising islands. Thus between Lakes Erie, Huron and Ontario a true beach is found at 1,690 feet above the sea, around a small island rising thirty feet higher. With the rising of the land, barriers were brought up about this lake region, producing lake (or perhaps gulf of) Warren—a name given to the sheet of water covering the basin of all the great lakes. A succession of beaches of this lake have been partially worked out in Canada, Michigan, Ohio, Pennsylvania and New York, covering many hundreds—almost thousands—of miles. Everywhere the differential uplift has increased from almost zero about the western end of the Erie basin to three, five, and, in the higher beaches, from five to nine feet per mile. With the successive elevations of the land, this lake became dismembered, as described in the succeeding papers—and the present lakes had their birth. The idea that these beaches in Ohio and Michigan were held in by glacial dams to the northward, is disproved by the occurrence of open water and beaches to the north, which belong to the same series, and by the fact that outlets existed where glacial dams are required.

The Erie basin is very shallow, and, upon the dismemberment of Lake Warren, was drained by the newly

* Proc. of Am. Ass. Adv. of Sc.

constructed Niagara River, except, perhaps, a small lakelet southeast of Long Point. Subsequently, the northeastward warping (very much less in quantity than out farther northward at the Trent outlet) eventually lifted up the rocky ledge and formed Erie into a lake in recent times; thus Erie is the youngest of all the lakes. The beaches about Cleveland are not those of separated Lake Erie, but belong to the older and original Lake Warren.

Discovery of the Ancient Course of the St. Lawrence River.

Previous investigations by the author showed that there was a former river draining the Erie basin and flowing into the extreme western end of Lake Ontario, and thence to the east of Oswego, but no further traceable, as the lake bottom rose to the northeast. Upon the southern side there was a series of escarpments (some now submerged) with vertical cliffs facing the old channel. By recent studies of the elevated beaches it is demonstrated that the disappearance of this valley is due to subsequent warpings of the earth's crust, and that the valley of the St. Lawrence was one with that of Lake Ontario. Recent discoveries of a deep channel upon the northern side of Lake Ontario (a few miles east of Toronto) and of the absence of rocks to a great depth in the drift below the surface of Lake Huron, between Lake Ontario and the Georgian Bay, and in front of the Niagara escarpment between these lakes; of the channel in Georgian Bay, at the foot of the escarpment, and of the channel across Lake Huron, also at the foot of a high submerged escarpment across that lake, show that the ancient St. Lawrence, during a period of high continental elevation, rose in Lake Michigan, flowed across Lake Huron and down Georgian Bay, and as drift filled the channel to Lake Ontario, thence by the present water to the sea—receiving on its way the ancient drainage of the Erie basin and other valleys.

The paper awakened a warm discussion, in which Professors Cook, Newberry, Wright, Winchell, McGee and

Hitchcock took part. The author's conclusions were upon observed facts in the field, some of which ran against some extreme forms of the glacial theory.

Discovery of the Outlet of the Huron—Michigan—Superior Lake and Lake Ontario by the Trent Valley.

With the continental rise described in the last paper—owing to the land rising more rapidly to the northeast—Lake Warren became dismembered, and Huron, Michigan and Superior formed one lake; the Erie basin really was lifted out of the bed of Lake Warren and became drained, and Ontario remained at a low level. The outlet of this lake was southeast of Georgian Bay, by way of the Trent valley, into Lake Ontario (at about sixty miles west of the present outlet of this lake). The waters of this upper lake were twenty-six feet deep over this outlet into the Trent valley, and long continued to flow through a channel from one to two miles wide. It has cut across a drift ridge to a depth of 500 feet, as the whole area has been rising. With the continued continental uplift to the northeast (which has raised the old beach at the outlet about 300 feet above the present surface of Lake Huron) the waters were backed southward and overflowed into the Michigan basin and into the Erie, thus making the Erie outlet of the upper lakes to be of recent date. This is proven by the fact that the Georgian beach which marked the old surface of the upper great lake descends to the present water level at the southern end of Lake Huron, and is beneath the surface of the water upon its southwestern side, as the uplift, which has been measured, was to the northeast.

The two questions involved are "origin of the valleys" and "cause of their being closed into water basins." The basins of Lakes Ontario and Huron are taken for consideration. The previous paper upon the course of the ancient St. Lawrence shows that the Huron and Ontario basins are sections of the former great St. Lawrence valley, which was

bounded, especially upon the southern side, by high and precipitous escarpments, some of which are submerged. But upon their northern sides there are also lesser vertical escarpments, now submerged, with walls facing the old valley. The valley was excavated when the continent was at a high altitude, for the eastern portion stood at least 1,200 feet higher than at present, as shown by the channels in the lower St. Lawrence, in Hudson's straits, and in the New York and Chesapeake bays. The valley was obstructed in part by drift, and in part by a north and northeastward differential elevation of the earth's surface, due to internal movements. The measurable amount of warping defied investigation until recently, but now it is measured by the amount of uplift of beaches and sea cliffs. Only one other explanation of the origin of the basins has been given—the "Erosion by Glaciers." (a) Because the latter occur in glaciated regions. (b) That the glaciers are considered (by some) to erode. (c) The supposed necessity, as the terrestrial warping was not known.

In reply: Living glaciers abrade, but do not erode, hard rocks, and both modern and extinct glaciers are known to have flowed over even loose moraines and gravels. Again, even if glaciers were capable of great plowing action, they did not affect the lake valleys, as the glaciation of the surface rocks shows the movement to have been at angles (from 15° to 90°) to the direction of the side of the vertical escarpments against which the movement occurred. Also the vertical faces of the escarpments are not smoothed off, as are the faces of the Alpine valleys, down which the glaciers have passed. Lastly, the warping of the earth's surface in the lake region, since the beach episode, after the deposit of the drift proper, is sufficient to account for all rocky barriers which may obstruct the basins.

THE STUDY OF MINERALOGY.

By T. STERRY HUNT, LL.D., F.R.S.

(*Abstract.*[1])

§ 1. Our knowledge of the inorganic kingdom, as seen in this earth, may be comprehended under geography, geology and mineralogy; the latter in its wider sense including all non-organised forms of matter, with their whole dynamical[2] (physical) and chemical history. In didactic language, however, minerology is limited to the study of native species, and includes a knowledge alike of their external characters and their chemical relations. The so-called natural-history method in mineralogy, disregarding these latter, is based exclusively on specific gravity, hardness, optical characters, texture and structure, including crystallization; while the chemical method regards the results of chemical analysis alone, and mixed methods consider these in connection with crystallization, and even endeavour to take into account other physical characters. The defects of all the methods hitherto devised are obvious, and no system of classification can be complete which does not assign a value and a place to all characters whatsoever. There exists in the nature of things such an interdependence of these, that

[1] Read before the British Association for the Advancement of Science, Bath, 1888.

[2] We use the words dynamics and dynamical in the sense in which they are employed by Thomson and Tait in their treatise on *Natural Philosophy*, wherein all those manifestations of force which are neither chemical nor vital (biotic), including, besides ordinary motion, the phenomena of sound, temperature, radiant energy, electricity and magnetism, are embraced under the general title of Dynamics, corresponding to what in popular language is designated Physics. Other eminent students of our time have sanctioned this use of the term dynamics, in which they were to a certain extent anticipated by Berzelius, who in 1842 included electricity, magnetism, light and heat—all of which he regarded as affections of matter, and compared their phenomena with those of sound—under the common term of Dynamides. (See Hunt, *Mineral Physiology and Physiography*, p. 13.)

a true natural system can exclude none. To the establishment of such a system, a clearer view of the nature and relations of physical and chemical phenomena than that generally received will materially aid us.

§ 2. Matter is susceptible of changes of volume of two kinds. (1) Those produced from without, by variations of temperature and of pressure, which changes are constant and regular. Effecting no essential alteration in species, they may be called *extrinsic* or, as the result of external dynamic agencies, *mechanical* changes. (2) Those which have been described as due to "internal disturbances," which effect specific alterations in character. These constitute *chemical* or what may be called *intrinsic* changes, and differ from the last in that, instead of being constant and regular, they are periodic and subordinated to definite and unforeseen relations of volume. Intrinsic changes of volume in matter connote chemical as distinguished from dynamical processes. In chemical union we have intrinsic contraction or condensation (variously designated as interpenetration, compenetration, identification, integration, unification); and in chemical decomposition, intrinsic expansion or division. These changes may be either homogeneous, involving one species of matter, or heterogeneous, involving two or more species. The first includes so-called polymerization and depolymerization, which may be described as homogeneous intrinsic union and homogeneous intrinsic division; constituting what we have called collectively *chemical metamorphosis.* Those intrinsic changes which involve two or more species we have included under the title of *chemical metagenesis;* the process being one of heterogeneous intrinsic union or of heterogeneous intrinsic division. In the former, intrinsic contraction involves volumes of unlike species, and in the latter, intrinsic expansion resolves a species into two or more unlike species. The relations to volume of all such changes are most simple and evident in the case of gases and vapours; but the same laws of intrinsic contraction and expansion by volumes apply alike to gases and to the liquid and solid species

formed by their condensation. In all of these chemical changes temperature and pressure play an important part, and, beyond certain limits the intrinsic or dynamic changes thereby produced, themselves provoke chemical changes. These in their turn are accompanied by thermic changes, the study of which is the object of thermo-chemistry.

§ 3. All chemically stable forms of matter may theoretically, by sufficient elevation of temperature, assume, even under the greatest pressure, a gaseous condition; the more or less dense polymeric vapours thus produced being subject to intrinsic expansion or depolymerization on diminution of pressure. By reduction of temperature these pass, as may be seen under favourable conditions, through successive polymerizations, or processes of intrinsic contraction, into liquid (or solid) species; the passage from the vapour to the liquid being apparently continuous. The ideal gas is wholly obedient to the dynamic influence of pressure, according to Boyle's law, to which the ideal solid is wholly indifferent. These ideal forms are, however, constant only within certain limited ranges of temperature and pressure, beyond which even the so-called permanent gases become liquid or solid by intrinsic changes.

The regularity of the extrinsic variations in volume for gases and vapours, within certain known limits, enables us for such bodies to determine their specific gravity, for which purpose atmospheric air at 0° and 760 mm. is taken as unity. If for this we substitute hydrogen gas represented as H_2=2·0), the lightest body known, at the same temperature and pressure, the specific weight of an equal volume of any given vapour or gas, calculated for this standard temperature and pressure, is its equivalent weight, or in the language of the popular hypothesis, the molecular weight of the species. Extending the same method from normal gases and vapours to polymeric vapours, and thence to liquids and solids, and remembering that none of these forms are stable beyond certain ranges of temperature and pressure, we proceed to determine the specific gravity of all such bodies in terms of the same gaseous unit; the num-

ber thus obtained being for each body its equivalent weight. We thus find, as has long been suspected, that the equivalent (or so-called molecular) weights of liquid and solid species are exceedingly elevated. That of water, a litre of which at 100° (its temperature of formation under a pressure of 760 mm.) weighs 958·78 grams, corresponds to 1192 volumes of water vapour at standard temperature and pressure (H_2O=17·96) condensed into a single volume; or to 1192 × 17·96=21,408, approximately 21,400. Representing by p the empirical equivalent weight, which is really the specific gravity on the hydrogen basis (H_2=2·0), and by d the specific gravity taking water =21,400 as unity, we obtain by the formula $p \div d = v$, the reciprocal of the coefficient of the condensation which takes place in the passage of a normal gaseous species, by intrinsic contraction or polymerization, into the liquid or solid species, the specific gravity of which we have determined by comparison with water.

§ 4. The reciprocal number thus got is, as we shall show, one of great significance. In determining the specific weight of any given liquid or solid species, the fact of prime importance is not simply its specific gravity as compared with water, but the relation of the value thus determined to the equivalent weight, or, in other words, to its specific gravity on the hydrogen basis. It is not d, nor yet p, but the relation $p : d$, as expressed by v. In the case of volatile species the true value of p may be known, but for the comparison of fixed solids, as oxyds, carbonates, and silicates, we deduce from the received formulas an arbitrary value for p by dividing the value calculated therefrom by twice the number of oxygen portions. Thus for MgO, p=40÷2; for SiO_2, p=60÷4; for Al_2O_3, p=102÷6; for $SiMg_2O_4$, p=140÷8; for $CCaO_3$, p=100÷6. For metalline minerals, including metals, and their compounds, with S, Se, Te, As, Sb, Bi, the value assumed for p is that got by dividing the empirical equivalent weight by the sum of the valencies.

While the specific gravity of liquid and solid species is represented by d, the hardness, infusibility and insolubility or resistance to chemical change are, for related species,

directly as the condensation, or inversely as the value of v. This may be seen in comparing colourless ordinary phosphorus, $v=17 \cdot 2$, with the metalloidal form, $v=13 \cdot 2$; the isomeric silicates, meionite, $v=6 \cdot 5$, and zoisite, $v=5 \cdot 3$; or calcite, $v=6 \cdot 2$, with dolomite, chalybite and diallogite, $v=5 \cdot 2$, and with magsenite and smithsonite, $v=4 \cdot 7$; for aragonite, $v=5 \cdot 55$. These examples will serve to show the relations between sensible characters and chemical constitution, the interdependence of which must be taken into account in a natural system of mineralogical classification. The differences in hardness and in solubility of the different species just named are familiar to chemists. The behaviour of native silicates with fluorhydric acid, lately studied by J. B. Mackintosh, illustrates in a striking manner the relations between condensation and solubility.

§ 5. The successive forms imposed upon matter gives us the order in which such a system of mineralogy should be built up. First, the form which we may call the *chemical form* of the species, either elemental or compound, due to the unknown stochiogenic process, or to subsequent chemical metagenesis. Second, what may be called the *mineralogical form*, which involves the greater or less intrinsic contraction (polymeric condensation) of the normal chemical species—often gaseous or volatile, but frequently unknown to us—and the assumption by it of a liquid or solid state, having greater or less specific gravity, hardness, fixity and insolubility, and being metallic or non-metallic, colloidal or crystalline. Third, the *crystalline form*, being the geometric shape assumed by the crystalline individual, which connotes a certain structure, apparent in the cleavage, the varying hardness, and the thermic, optical and electrical relations, of the crystal, but is, notwithstanding its value in determinative mineralogy, the least essential or most accidental form of the mineral species. The significance involved in the note of metallicity is very apparent when we consider the metallic and non-metallic conditions of selenium and of phosphorus, the similar dual conditions of the sulphide of mercury and antimony, the non-metallic and sparry characters of the

native sulphids of zinc, cadmium and arsenic, and the singular metallic character assumed by the complex tungstates or Tungstometalloids, known as tungsten bronzes. These, with the not less remarkably complex soluble tungstates or Tungstosalinoids, and the native tungstic species, make the Tungstates one of the most instructive orders known.

§ 7. The author has elsewhere proposed to divide the mineral kingdom into four classes, including (1) Metalline, (2) Oxydized, (3) Haloid, (4) Pyricaustate (combustible or fire-making) species. Each of these classes is again divided into orders, tribes, genera and species. In the first class a single order includes two sub-orders and nine tribes, named (1) Metalloideæ; (2) Galenoideæ, including three sub-tribes corresponding to sulphur, selenium, and tellurium compounds; (3) Bournonoideæ; (4) Pyritoideæ; (5) Smaltoideæ; (6) Arsenopyritideæ; (7) Spatometalloideæ; (8) Sphaleroideæ; (9) Proustoideæ; each tribe including one or more genera. Again, in the second class are grouped under different orders, Oxyds, Silicates, Carbonates, Borates, Sulphates, Phosphates, Tungstates, &c. Three sub-orders of silicates include protoxyd, protoperoxyd and peroxyd silicates; among peroxyd bases being reckoned aluminic, ferric, manganic, chromic, bismuthic, and also, for special reasons, zirconic oxyd. Recognising in each sub-order various types designated Hydrospathoid, Spathoid, Adamantoid or gem-like, Phylloid or micaceous, and Porodic or colloidal; the tribes may be named Pectolitoid, Willemoid, Amphiboloid, Talcoid, Ophitoid, Zeolitoid, Feldspathoid, Granatoid (garnet-like), Micoid, Pinitoid, Perzeolitoid, Eulyioid, Topazoid, Pyrophilloid and Argilloid. Soluble saline species in any order are referred to a salinoid type, as Borosalinoid, Tungstosalinoid. The extension of this system to the Haloid and Pyricaustate classes is easy, and has been elsewhere explained.

The work of arranging in genera and species, with a Latin binomial nomenclature, and the determination for each species of the value of v, is now nearly complete for the first two classes; and the whole will probably soon

appear, with a proper introduction, as a Systematic Mineralogy, to be followed by a Descriptive Mineralogy. The general principles here set forth are discussed at length in the author's "Mineral Physiology and Physiography" (Boston, 1886), pp. 279-401, where, in a chapter entitled "A Natural System in Mineralogy," will be found an examination of the constitution and relations of the known natural silicates arranged in tribes, and tabulated, with the calculated values of v, and a new quantivalent chemical notation. See farther, a paper on "The Classification and Nomenclature of Metalline Minerals,"[1] discussing Class I, in the "Proceedings of the American Philosophical Society" for May 4, 1886, and in the *Chemical News*, August 10 and 27; also the author's "New Basis for Chemistry," 2nd edition (Boston, 1888), where, in chapters vii. and xiv., many points in the proposed mineralogical classification are elucidated.

MINERALOGICAL EVOLUTION.[2]

By T. STERRY HUNT, LL.D., F.R.S.

(*Abstract.*[3])

In a paper read by the author in 1887, before the Geological Section of the British Association for the advancement of Science, on The Elements of Primary Geology, it was said that the "transformation of the primitive igneous material of the earth's crust through the action of air and water, aided by internal heat, presents a mineralogical evolution not less regular, constant, and definite in its results than the evolution apparent in the organic kingdoms." The details of this complex evolutionary process,

[1] An abstract of this paper, printed in the programme of the Royal Society of Canada, without revision or correction by the author, will be found in the *Chemical News* for June 29, 1888.

[2] Read before the British Association for the Advancement of Science, Bath, 1888.

[3] *Transactions*, p. 704; also *Geological Magazine*, November, 1887.

as explained by what the writer has named the crenitic hypothesis, have been elsewhere set forth at length, on more than one occasion, and involve the whole chemical history of the various mineral species which enter into the constitution of rock-masses, but especially their relations to subterranean changes under the influence of heated water, and to atmospheric action. As we have pointed out, the transformation of basalt into the hydrous porodic body known as palagonite, and the subsequent partial conversion of this into a crystalline zeolite, as described by Bunsen, furnishes a significant illustration of the process under consideration.

The stability of silicated species under atmospheric influences is very variable, some being readily decomposed, and others very permanent; the indifference or chemical resistance, moreover, increasing with the hardness or mechanical resistance. These two qualities vary for species of analogous constitution directly as their condensation; while for species of similar condensation and hardness, the chemical indifference increases as alumina takes the place of the ordinary protoxyd-bases, lime, magnesia, ferrous oxyd and alkalies—a fact readily explained by the comparative insolubility of alumina and aluminous silicates in atmospheric waters. The less partial action of dilute fluorhydric acid on the various silicates shows more clearly than the atmospheric process, the relation of condensation to chemical indifference. This relation may be made evident by a few examples. The condensation being inversely as the so-called atomic volume, we find that when calculated by a simple formula (elsewhere given by the author) for all silicates and oxyds, this value, represented by v ($=p \div d$) for the various feldspars and scapolites, for nephelite, iolite, and petalite, equals 6·8–6.2; for the muscovitic or non-magnesian micas, 5.9–5·6; for garnet, epidote, zoisite, and the various tourmalines, 5·4–5·3; for staurolite and spodumene, 4·9; and for andalusite, topaz, fibrolite, and cyanite, 5·0–4·5, approximately. Comparing with these the common protoxyd-silicates, we find for wollastonite and

willemite, $v = 6 \cdot 6$; for amphibole, 5·9; for pyroxene and enstatite, 5·5; for chrysolite, 5·4–5·3; and for phenakite, 4·6. In the sub-aerial decay of crystalline rocks, while feldspars and scapolites among aluminiferous silicates are kaolinised, the micas, notwithstanding their laminated structure, are much less readily changed; and garnet, epidote, tourmaline, andalusite, and topaz are found unaltered with the quartz, corundum, spinel, cassiterite, and magnetite left behind by the decay of the feldspathic rocks—a process in which even amphibole, pyroxene, and chrysolite share. "The greater stability of those [silicates] which belong to the more condensed types is shown in their superior resistance to decay, and is thus of geological significance."

While the above are examples of the varying resistance to the atmospheric influences of carbon dioxyd and water combined, other changes less well known take place in silicates by the subterranean action of watery solutions, where a greater insolubility determines the formation of certain softer hydrated magnesian and aluminous species by epigenesis from harder and more condensed species. The production of these epigenic products, as was said in 1885, is due to their "chemical stability under the circumstances," and it was added, "The constancy in composition and the wide distribution of pinite show that it is a compound readily formed and of great stability." Such being its character, it might be expected to occur as a frequent product of the aqueous changes of other and less stable silicates. It is met with in veinstones in the shape of crystals of nephelite, iolite, scapolite, feldspars, and spodumene, from each of which it is supposed to have been formed by epigenesis. Its frequent occurrence as an epigenic product is one of the many examples to be met with in the mineral kingdom of "the law of the survival of the fittest." It is, however, difficult to assign such an origin to beds of this (described as dysyntribite and parophite), which are probably the results of original deposition or of diagenesis.

Mr. E. A. Ridsdale, who during the present year (1888) has done good service by publishing a suggestive essay

called "Notes on Inorganic Evolution," speaks of the production and conservation of more stable species, as above described, as a gradual "selection of inert forms," and further, as "a survival of the most inert." But as inertness consists in stability, and in fitness to resist alike the chemical and the mechanical agencies which destroy other species, it is evident that this phraseology is but another statement of the formula of "the survival of the fittest."

The great principle of the change of the mineral matters which existed in former conditions of our planet, into other forms more stable under the altered conditions of later ages, is but an extenston to the mineral kingdom of the laws already recognised in astronomical and biological development. As was written in 1884, "That a great law presided over the development of the crystalline rocks was from the first my conviction, but until the confusion which a belief in the miracles of metamorphism, metasomatism, and vulcanism had introduced into geology had been dispelled, the discovery of such a law was impossible." To this we may add that "the great successive groups of stratiform crystalline rocks mark necessary stages in the mineralogical evolution of the planet;" and that the principles which we have elsewhere laid down will help us "to recognise the existence and the necessity of an orderly lithological development in time." The reader who desires to follow the questions here raised will find them discussed in the author's "Mineral Physiology and Physiography," (Boston, 1886,) at much length, in chapters v., vi., vii. and viii., and further noticed in the Appendix, p. 688, where will be found references to previous pages here cited.

AUTUMN FIELD DAY.

For the first time in its history, the Natural History Society this year instituted a new departure in its annual excursions, by providing an Autumn Field Day. The Society, however, is under great obligations to Mr. Gibb for causing it to adopt such a popular course, since it was his earnest and most cordial invitation to accept the hospitality of his country residence, that brought about such a result.

The Field Day was held on the 29th of September. The excursionists, to the number of one hundred twenty, proceeding to Abbotsford *via* the Canada Pacific, and there found a most hospitable welcome and an abundant provision for all their wants. Immediately upon arrival the various announcements for the day were made, after which the party had abundant opportunity to inspect the large and valuable orchards in the immediate vicinity, where, thanks to the energy of Mr. Gibb, a centre of fruit culture is gradually being built up, which is destined to produce an important influence upon the fruit industry of this Province. Mr. Gibb himself has a large number of important varieties of Russian apples, and also a valuable collection of ornamental and forest trees, the adaptability of which, to this climate, he is endeavoring to determine.

After a bountiful lunch, the excursionists distributed in various directions under the leadership of Sir Wm. Dawson, Prof. Penhallow, Mr. Holden, Mr. Gibb and others. The largest party proceeded to the summit of Yamaska Mountain, whence a most extended view of the surrounding country was obtained, and where Sir Wm. Dawson delivered an address upon the peculiar geological features of the vicinity.

The collections made were chiefly geological, although a number of interesting botanical specimens were brought in, amongst others various species of Lycopodium, Agaricus, Aster; a number of ferns and Geranium Robertianum. On re-assembling at the house, addresses on the Natural History of the locality, were made by Sir Wm. Dawson and Prof. Penhallow, and a vote of thanks tendered Mr. Gibb by Prof. Bovey.

The day was fine, notwithstanding a snow-storm on the summit of Mount Yamaska, and the party returned to the city with the feeling that it had been a day of much pleasure and great profit.

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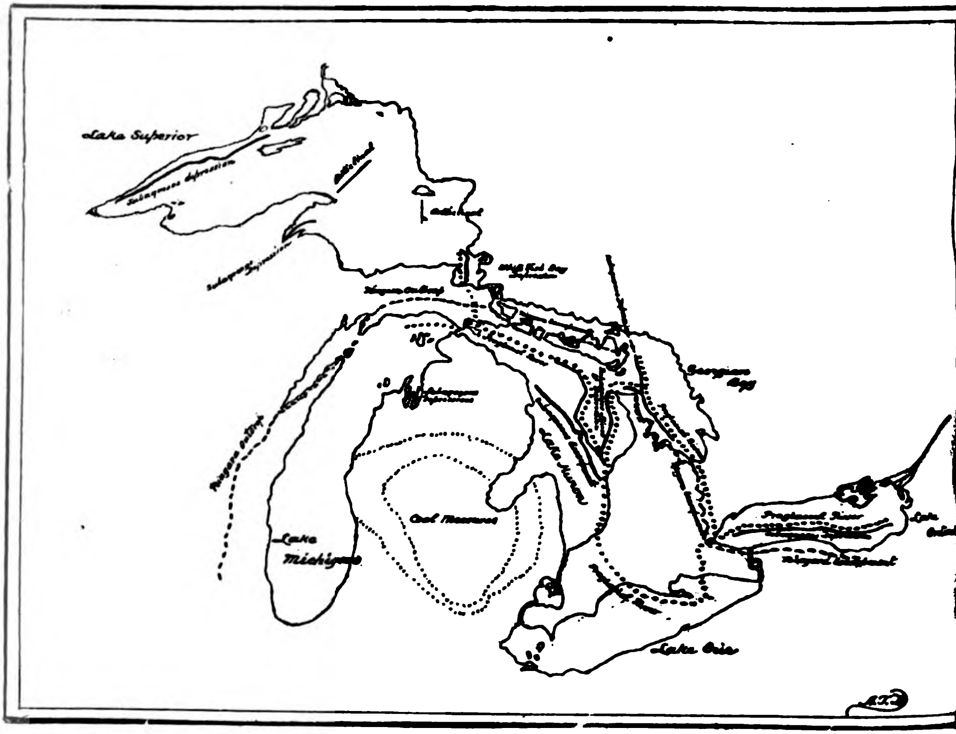
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THE

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The Great Lake Basins of The St. Lawrence.

By A. T. Drummond.

When recently considering the physical and geological relations of the Canadian flora, my attention was drawn to the many interesting questions connected with the formation of the St. Lawrence Great Lake Basins. What had been their history in past time? Were these lakes, as has been so long maintained, the outcome of the forces of the glacial age, or had they not in some cases an antecedent, and in others, or all, a subsequent history as well? What influences had they exercised on the climate, fauna and flora of the north-eastern part of the continent in the past? How far do their present contours and depths, the physical

Author's Note.—Since this paper was written, I have seen the very brief abstracts of articles on a similar subject by Prof. Spencer, which have been pnblished in the Record of Science for October, issued this month. I am glad to find that his views on one or two points referred to in this paper confirm the conclusions I had arrived at independently.

November, 1888.

and geological features of the surrounding country, the fauna of their depths, and the flora of their shores, furnish us with facts for the compilation of their history?

The object of the present paper is to suggest what has been the origin of the contours of the Great Lakes as they now present themselves. All writers on the subject are probably agreed that at a relatively recent quaternary period these lakes have been united consequent on a depression of the land, greatest at Lake Superior, and lessening towards the present St. Lawrence outlet. That in the previous glacial period this greater lake was a still larger inland sea extending farther southward, into which glaciers from the then more elevated Laurentian area, and rivers having their sources at the glaciers, flowed, and across whose surfaces floated icebergs and icefloes, carrying their burdens of boulders and debris in the direction in which the currents impelled them, has always appeared the most reasonable view to take. The depression would be a natural result of a rise of land to the north. It has not hitherto been sufficiently considered that whatever changes in level take place, the maintaining of an equilibrium in the earth's crust can in general terms be predicated. If there is a great subsidence in the land over any extended area, it may be assumed that there is a corresponding rise in the land over some other area. Thus, if over the Laurentian region there was an increase in height which gave some slope and consequently denuding power to the glaciers which flowed to the north and northeastward on the one side of the Laurentian axis, as shown by Drs. G. M. Dawson and Bell, and to the southwestward on the other, then we can accept the assumption that immediately to the southward or northward, or both, there might reasonably be an extensive depression of the land and an inflow of the sea. This inflow on the southward side also found its way, no doubt contemporaneously, as far west as the Rocky Mountains, as the enormous boulders and other features discovered by Dr. G. M. Dawson indicate. And there seems to be corroborative evidence of this inflow in the flora around the lakes

and in the fauna of their depths, as will be shown hereafter. That in the St. Lawrence Basin this inland sea graduated by a general elevation of the land and by local warpings of the strata into the more circumscribed fresh-water lake before referred to as including the area of the present lakes, there seems no question. That, however, prior to this an interglacial period prevailed, to be followed by a second glacial period, there is not in Eastern Canada very satisfactory evidence, whatever credence we may give to the vegetal deposits relied on by some American geologists to prove more than one interglacial period, and to the peaty remains in the Canadian superficial deposits towards the Rocky Mountains.

The grave difficulties which on general physical grounds stand in the way of the larger conception of a continental ice-sheet, need not be repeated here. It may be well, however, to allude to one circumstance—the immense mass of the superficial deposits—which has been relied on as necessitating a glacial theory for its explanation, and which has a direct association with the history of the St. Lawrence Basin. It has been usual to ascribe largely to glacial action what must be the effects of ages of subæreal and sub-aqueous erosion and decay in this great lake basin since the Carboniferous age. Whilst most sections were above water for vast periods prior to the Carboniferous, the whole of the immense area drained by the Great Lakes has, subsequent to that period, and as far onwards as quaternary times, been dry land, excepting to the extent that these lakes, or any of them, may have themselves been in existence during the immense intermediate periods—periods measured not by centuries alone, but probably by countless centuries of centuries. All of the agencies ordinarily at work in producing growth, disintegration and decay were then in operation, and have been continuously since. Forests covered the land, and vegetation in its decay everywhere yearly contributed to the soil; torrents found their way to the rivers, and the rivers to the lakes and to the ocean, creating on their way boulders and gravel, and depositing clays and

sands, not only on the river banks, but carrying them to these lakes and to the ocean in vast quantities; the ocean and lakes were themselves not only great factors in erosion on their coasts, but were the distributors of sands and clays over great areas of their floors; whilst added to these eroding powers were the ceaseless forces of the atmosphere in the heat of summer, in the frosts of winter, in the downpours of rain, and in the blasts of the storm—each contributing its measure of energy in the wearing down of mountain sides and cliffs, the carrying away of soil, and exposing of vegetation to decay—an energy not especially visible in its effects in a single year or in a decade of years, but productive of vast results in the course of centuries. And this growth, disintegration and decay going on ceaselessly from century to century, and from age to age, must have created immense deposits of boulders, gravel, sand and clays, in every part of the country, prior to the advent of the glacial period. If Croll's view were accepted, that since a previous glacial epoch, which he appears to suggest occurred during the Eocene age, a period of 2,500,000 years has elapsed, we can form some conception of what must have been the results of denudation during the enormous time previous to as well as since that age. These deposits were no doubt largely added to, and in many cases re-arranged, but the denuding effects of the glaciers, considerable as they may have been on the superficial features of the country, have been greatly exaggerated.

Again, some geologists have been too ready to accept existing levels as the basis on which to found conclusions regarding the levels of the country in its different sections in past times, without any reference to warpings of the strata which have since affected local or wide areas. These warpings are known to have cut through the channels of rivers, created new watersheds, opened up new river valleys, and reversed the currents of lakes. Spencer has recently drawn attention to such warpings in the Mississippi Valley and south of Lake Ontario.

CENTRES OF DEPRESSION.

When examining attentively the general geological features of the country surrounding the Great Lakes, the careful student will not fail to observe that three great centres, as it were, of depression existed in its bygone history.

One occupies nearly the western half of Lake Superior, the floor of which here is overlaid by the Cambrian and upper division of the Keweenawan rocks. Beyond these, on the north-west and south-east sides of this part of the lake there occur, in successive descending order, the lower division of Keweenawan, the Animikie division of the Huronian, and what are supposed to be the Laurentian rocks.

Eastward of Lake Superior, it will be observed that, as far onward as the Carboniferous period, there were, near the present lakes, two other great centres, as it were, of depression, the one in Northern Pennsylvania, the other in Michigan. In passing southward from the Laurentian region lying between the Georgian Bay and the Upper Ottawa, the formations are met with in a regular, almost unbrok en, ascending order, from the Laurentian of Canada, through the Lower and Upper Silurian and Devonian, until the Carboniferous rocks of Northern Pennsylvania appear. The strata representing these formations occur in this regular succession, all within a distance from north to south of one hundred and seventy-five miles. The outcrops of several of these formations are, on the south side of Lake Ontario, more or less parallel to the length of the lake and to each other, whilst the outcrop of the Trenton and Black River limestones to the north of the lake runs in a line diagonally from the east end of Lake Ontario to the Georgian Bay.

That the area presently occupied by Lake Ontario was overlaid in part by Trenton limestones and Utica slates, but perhaps more by rocks of the Hudson River and Medina age, is apparent from the way in which these strata on the north-western side are again represented to the eastward and southward of the lake. Thus, the interesting questions

to consider are: Do these strata presently form the floor of the lake, or have they within the lake area been removed by some vast erosive force acting at a recent period? In other words, is the lake the result of a synclinal depression or of erosion, or both? Again, is the apparent parallelism in the outcrops of the formations due to successive, gradual, permanent elevations of the land from the Laurentian period onward, each elevation stretching farther south than its predecessor, or is it due to a great erosive force which exposed in succession the upturned edges of the different strata, and as a farther result produced Lake Ontario?

In Michigan, again, the Carboniferous area which there at one time was the centre of depression, is even more conspicuous in its relations to both the surrounding geological features and the adjacent lakes. Here, on every side, there is a regular series of formations whose outcrops, after making every allowance for estimations, appear each in proper geological succession within the other, and in Michigan, form, as it were, irregularly concentric areas around the Carboniferous. Again, the contours of the shores of Lakes Michigan, Huron and St. Clair, and of Lake Erie at its western end, present the same idea of arrangement around the same central area. The interesting questions arising are: Were these formations originally laid down here with this more or less concentric arrangement which in Michigan they presently possess, or have they in recent or earlier times been the subject of some denuding force, which has given them this peculiar arrangement, and which probably has also aided in the creation or enlargement of the adjacent lakes? Again, as certain of these formations were evidently originally more or less continuous across the area now occupied by Lakes Huron and Michigan, has some vast erosive force created these lakes by removing the strata where they occupied the lake area, or do the strata underlie the waters of these lakes as a result of a depression, or, are there here the effects of both denudation and depressiou?

The central area of Michigan was, as far onward as the

close of the era of the coal measures, generally under water, and unless Michigan has been the subject of extreme denudation, those portions of the State which surround the coal measures were dry land when these measures were deposited. Since that period the State has been entirely above water, if we except any depression during quaternary times. Whatever the oscillations have been at different periods, the fact remains that the State is now in considerable sections elevated between one thousand and two thousand feet above the sea, the areas between the central and northern portions of the State forming the highest levels. In the country on the immediate west side of Lake Michigan, the land has, with the same exception, been above water since about the period of the Niagara limestones and shales, and is now there, in many sections, also between one and two thousand feet above the sea. In the Ontario peninsula, on the east side of Lake Huron, there is an elevation reaching on the anticlinal at the Niagara escarpment as high as seventeen hundred feet. There is, however, good evidence, as will be shown farther on, that at some former time there have been certain marked disturbances in the general level of the Michigan, Erie, Huron and Ontario areas, operating probably simultaneously, and that these disturbances had much to do with the more general defining of the contours of these lakes.

In following the history of the Great Lakes, the physical features of the lake bottoms afford some interesting chapters. The soundings undertaken by Cols. Meade, Comstock, and other engineers of the United States War Department, and those of Capt. Bayfield and Commander Bolton of the Canadian Marine Service, enable us to form some important conclusions, especially when taken in connection with the physical and geological features of the coasts of the lakes. That the lakes have to even a moderate extent a glacial origin does not appear to be borne out by the facts which these soundings reveal, however much icebergs and glaciers have contributed their quota of results to the outlines of some portions of the coasts and to the character and disposition of the material upon these coasts and upon the lake bottoms.

Let us examine each lake in turn.

Lake Superior.

This lake is so distinct from the other lakes in its origin, that it must be separately considered.

The point of greatest depth is not in the centre, but forty miles north-east of Duluth, and about six miles off the west shore, where, in a small area, 1,026 feet is reached, or 426 feet below ocean level. The depression to this low level at this point is, as frequently occurs elsewhere, very sudden, the depths at the immediate sides being 690 and 816 feet. The line of deepest depression at this end of the lake does not lie along or near the central line of the lake, but follows somewhat irregularly the west shore from near Duluth until it reaches the entrance to Thunder Bay. Between this bay and Isle Royale the maximum depth is 990 feet. From that part of this line of deepest depression, lying south-west of Isle Royale, the lake bottom shallows, at first somewhat gradually, but finally more rapidly to the south shore east and west of the Apostle Islands.

Along the west shore of the lake the coast line is often high, being in frequent places from 900 to 1100 feet, and at Thunder Cape attaining over 1300 feet. Below the water-line, for nearly the whole distance between Thunder Bay and Duluth, there is at or within a mile of the shore a sudden descent to depths varying from 100 feet in some localities to over 600 feet in others, whilst in one instance alongside the islands, off the east side of Thunder Cape, the bottom is only reached at 780 feet. Two miles further away from this general coast line the depth becomes 500 to 1000 feet. Thus along this west coast shore, from the summit of the heights overlooking the lake to the deeper points in the line of the depression, which is generally about five miles distant, there is a total descent varying from 1600 to 1900 feet, except at Thunder Cape, where it is increased to 2140 feet. These soundings suggest that between Black Bay and the westerly end of the lake there are, running

somewhat parallel with and close to the coast, great sub-aqueous cliffs, some probably like Thunder Cape, and of irregular outline and at different levels, and which give rise to the sudden increase in the depths of the lake here. There is, however, the possibility that a great downthrow, or dislocation, of the upper division of the Keewenaw Series, exists here, the hinge, as it were, of the depression being towards the south shore of the lake, and the rocks gradually sloping from this hinge to the line of deepest depression near the western shores. These cliffs lie in a general way parallel with the axis of the western end of the lake. Is it not suggestive that here we have the effects which gave rise in time to certainly the westerly half of this greatest of the inland seas? And may not the forces which resulted in these cliffs, or in this great dislocation, if such it be, have been simultaneous with some of those volcanic forces which at different periods produced the abrupt overflows, or great dikes, or interstrata, of the mainland in the Huronian or Keweenawan rocks, and gave direction to the heights which at its south-western end form there the rim, as it were, of Lake Superior. The Western sandstones of the south-west shore give further clue to their period of operation.

Parallel with these cliffs is another sub-aqueous escarpment in Keweenaw Bay, about twenty-five miles long, lying near the south-east shore and facing in the opposite direction. Here there is an abrupt descent from depths of 100 and 150 feet to depths varying from 300 feet to 552 feet. In the large outer bay the maximum depth is only 366 feet, and the average does not probably exceed 270 feet.

At the upper end of White Fish Bay the waters of Lake Superior converge, and flowing over the rocky rim of the lake here, result in the rapids of the Sault Ste. Marie, as they descend to the level of Lake Huron. The lake bottom in the bay has points of great interest. Running about due northward from near Pt. Iroquois, on the Michigan shore, past Parisian Island, on its western side, to opposite Pancake Point, on the Ontario side of the lake, a distance of

about thirty-five miles, is a marked depression in the floor of the bay of from three to four miles in width, flanked on both sides by more or less abrupt, continuous cliffs of probably Potsdam age. From a depth varying on the top of the cliffs from 30 to 150 feet, the descent is quickly made to depths reaching a maximum of 612 feet, and averaging from 350 feet to 400 feet. Whilst the summits of these subaqueous cliffs form, on either side of the depression, a relatively level surface of about two to four miles in width for the whole thirty-five miles, beyond that width the lake bottom once more, but more gradually, slopes in the one case to the eastward, in the other to the westward, so as to form two other depressions parallel to that above described, but of much less depth. Beyond Pancake Point the middle depression leads to the general depths of the lake bottom outside of the bay, but with a somewhat decreased depth at the immediate outlet. In White Fish Bay the lake bottom is, like the coast near at hand on the southern side, composed chiefly of beds of sand, and it is clear that these depressions are now partially filled up with this material and with clay.

These subaqueous cliffs and depressions lie in a general direction parallel to the eastern coast line of the lake, and have probably their origin in the same cause, though subsequently more defined by river action. The conspicuous subaqueous ridge between Michipicoten Island and the higher division of rocks of Caribou Island has apparently also the same direction.

The forces which contributed to the formation of Lake Superior appear to have taken three principal directions: the first in a line from Michipicoten Island eastward and westward, parallel with the extreme northern and general line of the southern shores of the lake, and with the northern coast of Keweenaw Point, where profound depths almost skirt the shores; the second, already referred to, operating in the line of the western coasts, of the subaqueous depression near these coasts, and of the axes of Isle Royale and Keweenaw Point, and of the Keweenaw Bay depression; and the

third, in a direction parallel with the eastern coast line, the White Fish Bay subaqueous cliffs and depression, and the apparent ridge between Caribou Island and Michipicoten Island. Other less important forces acted in other directions in forming Thunder Bay, Black Bay, with its deeply-channelled entrance, and the eastern and deeper side of Nepigon Bay. These forces probably operated at different times, each in its turn contributing to the further enlargement of the lake, which originally was no doubt of modest dimensions compared with the present area.

It is just probable that the operation of the second force in the order given above was more recent than that of the first, as a very marked subaqueous anticlinical in a line with and forming a continuation under the lake of the Keweenaw Peninsula, crosses to the centre of the lake, somewhat abruptly severing in two the deep, lake depression which runs from Michipicoten Island westward. There is a presumption that this anticlinal was formed subsequently to the depression, and, considering also the sandstones on the south-west coast, that the central part of the lake may thus be older than the south-western. Again, the Cariboo Island anticlinal apparently likewise crosses the deep, lake depression, and thus the central parts of the lake may also be older than the eastern. The White Fish Bay river channel being cut through the Potsdam sandstones, will also be more recent.

If we regard these earlier forces as having a common source with some of those which resulted in the eruptive rocks, forming so prominent a feature in, and so conspicuously interstratified with, the Huronian and Keweenawan Series, then we may date the origin of Lake Superior as far back as it may be Huronian and Keweenawan times. And this is by no means improbable. Foster and Whitney, and especially and more recently, R. D. Irving, have shown that the lake is, in both its eastern and western halves, a great synclinal trough or depression. This conclusion has been arrived at from—particularly in the western half—the generally constant dip of the Keweenawan rocks towards and

under the lake; the frequent dip of the Huronian as well; the re-appearance of these strata on opposite sides in the western half of the lake; the regular order of succession of Keweenewan rocks, Huronian rocks and gneiss, granite and crystalline schists on all sides when proceeding inland from the coast, and the parallelism between the courses of the Keweenawan belts on the north and south shores, and of the coast line with these belts.

At the eastern end of the lake, Cambrian rocks overlie the Keweenawan and Huronian, and now form the rim over which the lake waters flow in their course to Lake Huron. It is conceivable that the submerged channel fractured through these rocks here was, for ages, the outlet of Lake Superior into the Trenton, Hudson River, and later seas, and that even in more recent times it joined the submerged river channel in Lake Huron, coursing its way across the sandstones, limestones, and shales of the north peninsula of Michigan by a connecting valley which subsequent elevation of the land has cut off.

Now, all these facts appear to effectually dispel the idea that Lake Superior has a glacial origin. It is undoubtedly the oldest of the Great Lakes, and has preserved its present general contour through vast periods and for countless ages before the glacial period. That glaciers prevailed on the mountains and hills on its coasts during the ice age, polishing and grooving the rocks and dotting the united inland sea with ice and icebergs at certain seasons is probable, but they merely added to the effect of previous ages in toning down the rough edges of these mountains and hills, and scattering the loose material thus produced over the broad surface of the bottom. Great areas of this lake's bottom around the Apostle Islands, the west side of the Keweenaw Peninsula, and within and on the west side of White Fish Bay, are surfaced with sand derived undoubtedly from the wear of the sandstones of these localities, whilst the general character of the bed of the lake, especially in its most profound depths, is clay.

Dr. Selwyn thinks that the geological features of the

Lake Nepigon country may be explained by that lake now occupying the crater of an ancient volcano, and he is inclined to take the same view of Lake Superior. Whatever may be said of Lake Nepigon, the features of the present floor of Lake Superior hardly bear out this conclusion, although there can be no question of the existence of enormous volcanic forces at different points.

Whilst the history of Lake Superior, during the vast ages which have elapsed between the Cambrian period and the close of the Tertiary, is in most respects a complete blank, yet, from the latter time, its history begins once more. Apart from the facts which the superficial deposits supply, some reference to which will hereafter arise in connection with the other lakes, the fauna of the lake itself and the flora now existing around its shores afford some interesting chapters.

On the jutting headlands of the lake, and along the shores of the bays of its northern coasts, there are both subarctic and boreal plants which appear to form a completely isolated group in these localities. Their original presence, there, it is difficult to disassociate from a migration before the close of the glacial era, when, with the somewhat colder climate, and under the influence of the low equable temperature of the great inland sea south of the glacier-clad Laurentian and Huronian mountains, subarctic and boreal plants found a natural highway along the coasts. With lofty mountains to the immediate northward, such plants, as well as perhaps arctic species, were doubtless not uncommon. As the waters receded and the climate became milder, these northern plants were driven to localities like the headlands of Lake Superior, where the low temperature and moist atmosphere were favorable to the continuance of some of them in a struggle for life, in which probably most became extinct.

The inland maritime plants of Canada, which occur along the coasts of all the Great Lakes, and on saline ground in New York State, and far westward, appear to be the remnants of a larger maritime flora which margined the coast

probably before the close of glacial times, and certainly at a period when the great inland seas were saline, or in a state of transition from saline to fresh water, which the gradual change in the elevation of the land would have brought about. Their presence so far inland seems a direct argument for the saltness of this interior sea at these times, and under any circumstances proves, in connection with the subarctic and boreal plants of Lake Superior, that the climate, at the time of their migration, was not, along the shores of that lake more severe than on the coasts of the Lower St. Lawrence at the present day. These inland maritime plants are all now found there or on the coast of Nova Scotia. In further proof of this question of climate, does not the comparatively limited flora of the summits of the White Mountains, and other considerable heights in New England and New York, comprising chiefly four or five really arctic and a few subarctic and boreal plants, nearly all also found on the coasts of the Lower St. Lawrence, of the Gulf of St. Lawrence, or of the adjacent portions of Labrador, show that the true arctic flora had hardly, in glacial times, reached as far south as these mountains?

Profs. Verrill and S. J. Smith, in 1871, published in the *American Journal of Science* a list of the deep-water fauna dredged by them in Lake Superior. The list is interesting as shewing the existence in that lake as well as in Lake Michigan of the marine crustaceans *Mysis relicta.* Loven and *Pontoporeia affinis,* Lindst., previously detected in Lake Wetter in Sweden. Both species were discovered in the profound depths of the lake, as well as in the shallower waters. Species of *Gammarus,* which might possibly be marine, were also found. They are no doubt the survivors of a larger marine fauna which inhabited the St. Lawrence basin in glacial times, and would seem to afford proof of the saline character of the water of the great inland sea which occupied this basin when the subarctic, boreal and inland maritime plants migrated to the neighborhood of Lake Superior. The *Mysis* is a denizen of the Greenland seas, and suggests strongly that when the great inland sea prevailed

the temperature of its water was maintained at a low point by cold inflowing streams, by currents, and by icebergs. These crustaceans thus aid in identifying the conditions under which the northern and maritime plants existed on the inland coasts.

Lake Huron.

This lake presents a totally different set of circumstances from those of Lake Superior. Its floor is laid in the Archaean Silurian and Devonian formations, whilst the Niagara escarpment, continued across the Ontario peninsula, gives shape to the two great divisions into which the lake surface is separated in its northern half.

In its profound depths the lake really forms three great basins—the Georgian Bay, the Central, and the Southern basins.

The continuation of the great Niagara escarpment in an irregular, subaqueous ridge connecting Cape Hurd, the Grand Manitoulin Island, and the various islands between them, gives the Georgian Bay a distinctive character. This ridge appears to present, under water, bold, precipitous cliffs facing the Georgian Bay, similar to the heights from Cabot's Head to Owen Sound, and with similar deep inlets, though penetrating the ridge in somewhat different directions. Whilst the cliffs on the islands form the real summit of the ridge, and its subaqueous portions rise to an average of within 30 to 40 feet of the lake surface, the depths on its immediate eastern sides often reach 250 feet. At Overhanging Point, between Cabot's Head and Cape Hurd, the depth at half a mile from the cliff reaches 540 feet, the deepest point of the Georgian Bay. Through this subaqueous ridge there does not appear to be any break permitting direct access from the deeper waters of the bay to those of the central parts of the lake beyond. Further, the dip of the strata forming the ridge appears by the soundings to fall gradually to the westward and south-westward, just as the same strata on the Bruce Peninsula slope to the west-

ward, and those on the Manitoulin Islands in the curve which the outcrop of the Niagara limestones there takes, slope to the southward.

The Georgian Bay in this part appears to be subsiding, according to Bolton's survey. North-East Shingle, off Lonely Island, presently 2 to 5 feet below water, was in Bayfield's time, 3 to 4 feet above, whilst White Shingle, off Snake Island, now 1 foot below, was formerly 2 to 3 feet above. As Bayfield's survey was made in 1822, the maximum subsidence has been about one foot in each nine years. Commander Bolton, however, has personally suggested to me the possibility that floating ice may have been the cause.

On the eastern banks of the St. Clair River there are also evidences of subsidence, but these may be local.

It is possible that in some sections the Niagara escarpment, including under this term the whole strata exposed, may result partly from a fault. The country at the foot of and approaching the escarpment is in Canada, almost invariably either obscured by heavy superficial deposits, or covered by the waters of the lake, rendering exact observation difficult. It is quite possible that could the profound depths of the lake adjoining the east and north side of the Bruce Peninsula be studied, such a fault or faults might be discovered. Whilst the escarpment at Cabot's Head towers 324 feet above the water, the depths close at hand in the Georgian Bay reach about 498 feet, giving a total of 822 feet, and along the face of the escarpment lie the deepest parts of the Georgian Bay. From this line of depression the slope is upward towards the north-eastern shores of the bay, where the depths outside of the islands average about 60 feet, excepting in Parry Sound, where there is a maximum of 354 feet.

From Cabot's Head south-eastward, at every point and island, and sometimes also in the bays, Mr. Alex. Murray found a fringe of reefs close to the cliffs, all apparently composed of loose blocks, and probably all derived from the destruction of the cliffs by rapid currents, by the action of

waves, as well as by the forces of the atmosphere. These reefs also extend a short distance eastward of Owen Sound. Two or three miles to the eastward of these cliffs Commander Bolton has found at least two abrupt elevations quite near to the surface and covered with loose rocks.

Whether, however, there has been any special subsidence in the strata on the eastern side of the escarpment or not, the escarpment itself has been the subject of elevation, greatest at the edge of the cliff and gradually lessening to the westward on the Bruce Peninsula, and to the southward on the Manitoulin Island, until all of the strata are lost under the waters of Lake Huron proper. The soundings along the whole eastern coast of the lake from Cape Hurd to Goderich, and southward, and off the southern coasts of the Manitoulin Islands, show that the strata continue to slope gradually towards the central parts of the lake.

Another somewhat parallel escarpment occurs on the west side of Matchedash Bay, and along islands at the extremity of the peninsula there. This is, however, in the area of the Trenton and Black River limestones, near or at their junction with the Laurentian rocks. The strata slope from Nottawasaga Bay upward to Matchedash Bay, where they present bold cliffs facing to the north-east. The depth of water adjacent to the cliffs on these islands is very considerable, reaching a maximum of 267 feet.

The central and southern deep-water basins of Lake Huron are readily distinguished. The former, which is the deeper of the two, lies in the Upper Silurian strata, and is separated from the latter, which rests on the Devonian rocks, by a well defined escarpment evidently of Corniferous limestone. This escarpment, starting from the Canadian side south of Kincardine, crosses Lake Huron in a north-westerly direction in, generally, a line with the Straits of Mackinac until near Presqu'isle Point, where it approaches the shallower waters of the Michigan coast. If 180 feet in depth of water were uniformly removed from Lake Huron, it would completely separate these two basins and leave the summit of this separating ridge in some cases 120 feet above water.

While thus this ridge approaches in some places within 60 feet of the present level of the lake, the profound depths on the immediate north-easterly side vary from 360 to 588 feet.

The deepest point in the lake is 750 feet, or 172 feet below ocean level, and is found in this central basin about thirty miles south-west of Cape Hurd. It is a sudden depression, as the depths a short distance on either side are 426 and 366 feet, and it does not occur in the general line of deepest depression. This line, starting from near the Canadian shore, takes a direction irregularly parallel with the Corniferous limestone escarpment to a point somewhat more than half-way across the lake, when its direction is diverted northward towards Grand Manitoulin Island. A branch of this line of deepest depression runs from off Kincardine almost due north in an irregular line towards Cape Hurd. Lake Huron is thus somewhat deeper in its Canadian half, and the central basin gradually shallows to about 180 feet near the Straits of Mackinac.

The southern basin comprises all that part of the lake south of the subaqueous Corniferous escarpment, and is much shallower than the central basin. The summit of the escarpment has an average breadth of about four miles, after which, on the south-western side, the slope becomes more distinctly to the south-west or west, and is somewhat gradual, though the greatest depth in this southern basin is reached at 330 feet in an abrupt depression at one point, at the beginning of this slope, about midway across the lake. The depth over the greater portion of this southern basin is very moderate, and about its centre is a large area, lying somewhat north-west and south-east, where, though almost surrounded by deeper water, the depth does not exceed 180 feet, and is generally less.

Whilst the bottom of the central basin is chiefly clay, with gravel in places, that of the southern basin is largely sand, especially in its lower third towards the outlet at the St. Clair River, and in Saginaw Bay.

Saginaw Bay appears to be a subaqueous continuation of

the depression which crosses the State of Michigan along the Grand Valley and which, Rominger points out, seldom presents surfaces exceeding 100 feet above the lake. It does not average 30 feet in depth and it is suggestive whether it is not really a very shallow synclinal trough in the Carboniferous and Devonian rocks.

Now, all these facts, with others, have their bearing on the origin of Lake Huron. The abrupt, subaqueous Corniferous ridge diagonally crossing the lake; the different lines of direction of the Bruce Peninsula, its subaqueous extension and the Manitoulin Islands, and of their deep bays and inlets; the abrupt cliffs, both above and under water, showing rather the effects of undermining by waves and currents; the directions of the lines of deepest depression; and the varying and often sudden depths of the lake, showing that there has not been any general filling up of the hollows and depressions in the lake bottom, all militate against the idea that a great glacier from the north or north-east, gradually, in the course of ages, formed the depths and outlines of Lake Huron, nor do the directions of the ice grooves suggest what were evidently the travelling lines of the forces which gave rise to the above described and other physicial features of the lake. A reasonable conclusion, quite compatible with the existence of a fault, and with the elevation of the Niagara escarpment and of the land to the east of the Georgian Bay, would appear to be that the depression fronting this escarpment is in part the result of river excavation, and that through it flowed across Ontario, the drainage of the country to the northward and northwestward, until the waters joined the preglacial river which, as Spencer and Claypole point out, occupied the bed of Lake Ontario. This—supplemented by subsequent lake action—would account for much of the disintegration of the escarpment. The course of the river through Lake Huron was then, as shown by the line of depression, first to the south of eastward for some distance, then south towards the corniferous escarpment parallel to which it flowed, until, by a diversion to the north, it reached Cape Hurd and turning

eastward, joined this river channel in a great fall over the subaqueous ridge now worn back to a line between Cape Hurd and Grand Manitoulin Island. Another stream from the north joined it at this point. These great preglacial rivers would continue their flow until the elevation of the anticlinal between the Georgian Bay and Lake Ontario blocked their course, and filling the Georgian Bay with water, created a new outlet, not by the St. Clair River, but to the south-eastward of Lake Huron as hereafter referred to.

Though the eastern coasts, between the Bruce Peninsula and the County of Lambton, present bold clay cliffs of considerable height, the general dip of the strata from the Niagara escarpment which crosses Lake Ontario to the Georgian Bay, is towards and under the main body of Lake Huron. As already mentioned, this is also the case on the Manitoulin Islands, and south-eastward across the subaqueous escarpment to the Bruce Peninsula. Again, the strata on the Canadian side of Lake Huron proper appear on the Michigan side in the same relative positions. These facts tend to prove that the lake is in part now a synclinal trough which has been further depressed, in common with the surrounding country, at the time when the superficial deposits were formed, but which, in its rise to its present levels, has left behind the great clay cliffs now lining its eastern sides, which have been gradualy worn backwards by the action of waves and atmospheric causes.

The subject will be further referred to when discussing Lakes Michigan and Ontario, for the final shaping of the contour of these three lakes was in part due to one common cause.

Lake Michigan.

This lake rests, to a limited degree, on the Lower Carboniferous rocks, but chiefly on those of Upper Silurian and Devonian age. Its depth has been said to reach even 1,800 feet;[1] but the soundings made under the direction of the

[1] Encyclop. Britann. 9th ed. vol. 21, p. 178.

engineers of the United States War Department, do not indicate a greater depth than 870 feet, which is 292 feet below ocean level. This deepest point lies in the latitude of 44° 30' and rather nearer the Michigan than the Wisconsin shore. But a relatively limited portion of the lake has a depth exceeding 600 feet, and all of this portion is located in its northern half. The most northern parts of the lake are comparatively shallow, but there is clear evidence of a broad river channel cut through the rocky bed of the lake and running along the north side of the Beaver Island group to the Straits of Mackinac. Whilst the depth of the lake waters everywhere on either side is under 100 feet, this ancient river channel registers from 100 to 302 feet, the deepest points being in the narrowest parts of the Straits. From the Lake Huron side, another river channel entering the Strait, and with depths of from 154 feet to 210 feet, almost completes a circle around the Island of Mackinac, but is presently disconnected from the Michigan river channel by a narrow ridge or anticlinal, about two miles in width—the result of more recent warpings in the strata there—running from Point St. Ignace south-eastward, and over which there are now from 17 to 70 feet of water. These two subaqueous river channels were, without doubt, at one time connected, and at a previous period of these lakes' history, formed the outlet for the waters of Lakes Superior and Michigan. Both of these channels are flanked by the rocks of the Onondaga, Helderburg and probably Niagara groups, and have no doubt been enlarged by water action. It is at the same time a coincidence that in Lake Michigan the channel runs almost parallel with the northern coast of the lower peninsula of Michigan west of Mackinac and of the subaqueous ridge which connects the Helderberg rocks here with those of the Beaver Island group. Whilst this course is nearly due east and west, it will be noticed in this connection that the line of direction of the jutting headlands and islands immediately near them on the north shore, at and east of Mackinac Straits, is almost due south-east, and must be attributed to other causes.

The two peninsulas which defend the entrance to Green Bay are formed of the Niagara limestones which here curve to the south-west, and at Burnt Bluff and neighbouring points on the west side of the northern peninsula rise into an escarpment facing however to the north-west and west. Whilst at the base of this escarpment the water is, as a rule, comparatively shallow, the western side of the headland of the southern peninsula and of the adjacent islands carries deep water close to the shore, showing that the escarpment, continuing there, is in part, subaqueous, and faces also the north-west and west. It is important to observe these directions. Green Bay is however relatively shallow. The 100-foot line encloses a very limited area which, on the northern side, extends in a narrow, river-like prolongation, into Little Bay de Noquette, giving color, to that extent, to the possibility which Winchell has suggested, that in preglacial times there was a connection between the Lakes Superior aud Michigan basins by this bay and the Whitefish and Chocolate Rivers.

On the eastern side of the lake, Grand Traverse Bay in its upper half is divided by a long, narrow isthmus into two bays, each about twenty miles in length, and from one to two miles in width, with a general direction somewhat west of south. Though the outer bay which rests on the black shales has an average depth of 180 feet, these two inner bays are in reality narrow but abrupt and deep depressions varying in depth, in the one case, from 300 to 448 feet, and in the other from 300 to 612 feet. The lake bottom here is either clay, sand or rock. Lying almost parallel with these depressions are on the one side the long narrow lake known as Torch Light Lake, and on the other, the promontory which separates Grand Traverse Bay from the lake, and presents high bluffs on the western side. Originally these depressions were great fractures in the Devonian rocks, created by the elevation of the land here, just as the Niagara escarpment has been similarly fractured.

Between the Beaver Island group and the Manitou Islands is another extensive preglacial depression, in the rocky

bed of the lake, and with deep inlets joining it from the north, north-east, north-east by east, south and south-west sides, and the whole connected towards the south-west end with the deeper parts of the lake beyond. The descent is generally so abrupt from the shallower parts of the lake on either side to the depths of this depression and its inlets as to convey the idea of escarpments or bold cliffs almost surrounding the depression. The Helderberg anticlinal separates it from the old subaqueous river channel. On the other hand, Little Traverse Bay—another fracture in the Michigan coast—which has 130 to 230 feet of water everywhere within half a mile of its shores, may be said to lie about due east and west. It is important to thus note the varying directions of the forces which have given rise to these different depressions or great fractures.

The southern half of Lake Michigan has a generally uniform appearance. Its coasts are not indented with deep bays, but preserve an outline somewhat straight at the sides and curved at the southern end; the waters, though shallower towards this southern end, have on the eastern and western sides a gradually increasing depth towards the central plateau of the lake; the lake floor, excepting the anticlinal or warp in the strata between Milwaukee and Grand Haven, is comparatively level and somewhat, but not altogether, free from abrupt depressions; and whilst the lake floor in the northern half of the lake is frequently rocky, it is in the southern half almost entirely overlaid with clay or sand. These deposits of sand are much more general along the whole western and southern than on the eastern coasts, indicating at the time of deposition stronger currents towards these sides. In fact, the southern end of the lake in its general contour and depths, and in the character of its floor, corroborates the view that whilst an outlet to the Mississippi valley from the united lakes existed here, it also for a considerable time was an outlet of the present lake before its waters had receded to their present limits.

The section of country to the south and west of the southern end of the lake is largely prairie, that part imme-

diately surrounding the lake being but slightly elevated above its waters. At a very recent period these waters extended in shallows over the prairie country, giving it a marshy character. Parts of the land are still so low lying and wet as to be chiefly suited for grazing purposes. All of the level black-loam prairies of Northern Illinois and Indiana have at one time been of this marshy character, but by the annual growth and decay of the grasses, sedges and aquatic plants generally, the black loam soil has in the long lapse of time accumulated and the land has gradually appeared above the water. This extreme southern section of Lake Michigan has thus had its boundaries defined in their present outline within a period probably as recent as existing times.

Like Lake Huron the main portion of the lake is preglacial. The Wisconsin geologists, especially Winchell, Chamberlain and Salisbury, have strongly insisted not only on a continental ice-sheet covering Northeastern and Central North America in the glacial times, but on a great glacier having, during what they denominate the later glacial period, occupied among others, the Lake Michigan basin, whilst a separate smaller glacier overspread Green Bay and its surrounding country. Chamberlain thinks that Lake Michigan, in its regular outline and great depth and breadth, is due to glacial action, though it might have been deeply channelled by running waters in pre-glacial times. Like others of these geologists, he points to the so-called moraines running through Wisconsin, Illinois, Indiana and Michigan, some distance from but irregularly uniform with the coast line of the lake, as proof of the existence of the glacier. Now, it seems to me that the small extent of these moraines, if their, in general more or less, stratified appearance allows them to be called such, is ample evidence that if a glacier did occupy, for an immense period of time, the basin of the lake, its eroding power was small. If the great superficial area and depth of Lake Michigan had been excavated by the glacier, the accumulated debris forced to its edges would have been vastly greater than the moraines indicate, more especially

when we consider the extensive areas crossed by the glacier between the lake and the moraines, and the vast Laurentian and Huronian country to the northward, then more or less glacier-clad and supplying debris, apart from the accumulated debris of ages previous to this time. Prof. Claypole has encountered the same difficulty in discussing the so-called moraines to the south of Lake Erie.

The character of the floor of the northern half of the lake also presents difficulties. The direction of the old river channels and of the depressions, varying from east and west to north and south, the frequent abruptness of the descent to them, the directions of the axes of the promontories and neighbouring islands, and the absence of any general filling up of the hollows and depressions of the lake bottom in its northern half, all indicate that the glacier, if it existed, did not contribute to the forming of many of the leading outlines of the coast, or to the stamping of the chief features upon the lake floor. The subject will, however, be further discussed when referring to Lake Ontario in connection with this lake and Lake Huron.

Lake Ontario.

An important fact which at once strikes the observer, when noting the soundings in this lake, is that the areas of greatest depth are all towards the southern side of the lake. The deepest point is 738 feet or 506 feet below the ocean level, and is located about fifteen miles off the New York State side, between Rochester and Oswego. The 600-foot line here encloses an area of about thirty-eight miles long and ten miles broad, lying about parallel to the coast, and within eight miles of it. To this deep depression there is a fall of about 300 feet in two and a-half miles on its immediate southern side. On the northern side the descent is more gradual. Another depression exceeding 600 feet, but very small in area, exists about the seventy-eighth meridian of longitude, but similarily towards the United States side. Again, the 300-foot line encloses an area about

150 miles long and 24 miles broad, and in outline very like that of the present lake, but approaching the southern side within three to seven miles for the whole distance. The line of deepest depression along the length of the lake is also located about two-thirds of the way across the lake towards the New York State side. South of Port Credit and Toronto it takes the centre of the lake, but after that swerves towards the southern side. Preserving a depth of 540 to 570 feet for over sixty miles, it reaches the 600-foot line area, and finally begins to shallow at about nine miles off Oswego, where the depth is 576 feet. The evidence afforded by the terraces on either side of Lake Ontario would appear to show that, on the elevation of the land to its present limit, the rise was greater towards the north of the lake than to the south. This would cause the strata on the north side to dip towards the south, and force the waters of the lake more towards the southern side.

The lake bottom within the 600-foot line is chiefly mud, whilst outside, within the 300-foot line, it is largely clay and mud, with sand in occasional places. Close to the southern and eastern shores, rock is met with for the whole distance, but, with one exception, not elsewhere. The only large connected stretches of sand occur off and to the north-east of Oswego, suggesting, though not necessarily, an old outlet there.

Between Stony Point, off Sackett's Harbor, and South Bay Point, on the Canadian side, there is a rise in the level of the lake floor, culminating in the Duck and Galloo Islands. Between this limiting line and the outlet of the lake at Kingston, not only is the depth shallower—not exceeding 120 feet except in what may be two river channels, on either side of Duck Island, running inwards for ten miles towards Kingston—but its bottom is in nearly all directions rocky, and the contour of its shores—unlike the rest of the lake—is irregular, with deep bays and channels, which with the islands lie in a general north-east and south-west direction. The absence of the mud or clay which overspreads the lake elsewhere, and the two river channels opening towards the

lake, suggest that this section of the lake is more recent than the main basin beyond, and that the coast at one time may have been between South Bay and Stony Point. The conformation of the shores, the line of axis of the islands and the direction of the striæ at Kingston and of the limestone escarpment and striated Laurentian hills and gorge at Kingston Mills also suggest the action of a glacier from the north-east, whilst the whole would seem to show that at that time the lake outlet at Kingston did not exist. The absence of striæ on the surface of the limestones on the summit of the anticlinal at Fort Henry, near Kingston, though present in frequent places at the waterline, would indicate that the glacier here was not very thick. That the country around the present lake outlet has been in places subject to abrupt changes of level is shown by the heavily dipping limestones at Fort Henry and eastward, and the eruptions of granite through the syenitic gneiss and the limestone both here and farther down the river. There is some evidence to show that an eruption took place during the deposition of the Black River limestones, but the abrupt upheaval of these limestones at Fort Henry and Barriefield is conclusive that there were forces at work, operating in a somewhat westerly direction, subsequent to the Trenton and Black River, and possibly in recent, times.

That Lake Ontario has had a pre-glacial origin seems beyond question. Several causes have contributed to bring about its present outline and depth, and it may be that one or more of these causes operated after the glacial epoch. Towards the western and on the southern side the Medina sandstones and the Hudson River shales sink apparently north-westerly under the lake, at the eastern end the Trenton and Black River limestones dip to the east of south, and the general slope of these limestones between Kingston and Belleville is perceptibly towards the lake. There is thus some ground for the assumption that the Trenton limestones, Utica and Hudson River shales and Medina sandstones descend both ways under the lake waters, forming perhaps originally, in at least a part of the lake, a synclinal trough

which was affected by after changes. The relative positions of these strata around the lake further suggest this.

Another feature, however, has played an important part in the formation of not only Lake Ontario but also of Lakes Huron and Michigan, and even had its strong influence on Lake Erie as well. The Niagara escarpment, which nearly fronts the southern side of Lake Ontario, passes around its immediate westerly end, and then, facing to the north-east, continues in a somewhat irregular north-westerly direction until it eventually forms the prominent features of the Bruce Peninsula between the Georgian Bay and Lake Huron. At Cabot's Head, at the end of this peninsula, there is a break, but this is only apparent as there is a subaqueous ridge here, commencing near Cape Hurd, with deep water on the Georgian Bay side. This ridge, through the neighbouring islands, connects the peninsula with the Manitoulin Islands. The same limestones re-appear, crossing these islands, in bold escarpments facing to the northward, and extend uninterruptedly to the State of Michigan, the height diminishing to the westward. Along the northern shores of Lake Michigan they continue until Green Bay is reached, where, facing to the westward, they once more in places rise into an escarpment. Here they form two horns of the bay, with islands and another subaqueous ridge connecting them. Thence these limestones are found in the country skirting the western shores of Lake Michigan and they probably form the floor of its southern end beneath the superficial deposits.

The dip of the strata is, from the escarpment north of Hamilton and on the Manitoulin Islands, to and under the waters of Lake Huron. From Dundalk station on the Toronto, Grey and Bruce Railway, on the summit of the escarpment, there is a fall of 1,119 feet to the level of Lake Huron at Kincardine, seventy miles distant. South of the valley of the River Thames, which lies on the Cincinnati anticlinal, and at Niagara Falls, the slope is towards Lake Erie. To the north of the cliffs, on the Grand Manitoulin Island, are parallel escarpments of Hudson River age, form-

ing the bluffs on the northern side of the island, and with the strata dipping southward similarly to those of the Niagara age there. Again, the cliffs of Green Bay face to the westward, and the dip is easterly towards and under Lake Michigan.

This Niagara escarpment, in its course easterly from the western end of Lake Ontario, lies parallel to the axis of that lake, whilst in the other direct ion, it conforms in a general way to the course that more or less characterizes the outcrops of all the formations which, as it were concentrically, surround and underlie the coal measures of Michigan. The contours of Lakes Michigan and Huron and the Georgian Bay, and the subaqueous Corniferous escarpment crossing Lake Huron, also conform to this arrangement.

At the western end of Lake Ontario, the Niagara limestones in their outcrop suddenly change from an east and west course to one which is north-west and south-east. When these limestones were elevated into an escarpment, two separate lines of force appear to have operated—the one taking an easterly direction and causing the strata on the southerly side of the lake to dip in a southerly direction—the other taking a somewhat north-westerly course resulting in the strata thence to the Georgian Bay dipping more to the westward. These two forces appear to have, at the point of meeting, created a vast fracture in the escarpment near Hamilton, forming what ultimately became, chiefly through the eroding force of water, the Dundas valley. Again, between the Bruce Peninsula and the Manitoulin Islands, another change in the direction of the outcrop of both the limestones and underlying shales, caused, when the escarpment was elevated there, a series of great fractures which, by the action of the waves and currents and of atmospheric forces, and possibly of glaciers and icebergs as well, became, ultimately, the interrupted subaqueous ridge there. To similar fractures were no doubt originally due the narrow straits which divide the Manitoulin Islands from each other and the most westerly of them, Drummond Island, from the State of Michigan. Such fractures may

perhaps be found on the upper peninsula of Michigan, but much less pronounced in character, as the strata there have not been elevated to the same extent. Finally, there are the fractures which afford the entrance to Green Bay, and those which constitute the various bays around the whole front of the escarpment.

Now, these different facts are not mere accidental occurrences, and their conformity to each other is not a mere coincidence. They show that the oscillations of the earth's crust in this particular area, covering the State of Michigan, the larger part of Lake Huron, and the immediate country to the east of Lake Huron, and to the west of Lake Michigan have, from the Trenton period and probably earlier, been of a peculiar nature. These oscillations were confined to this area, and the forces which gave rise to them appear to have operated in conformity, in a general way, with the curved outline of the area and towards its centre. It is impossible to ascribe to glacial forces the varying directions of the outcrops of the different formations within this area, from the Trenton to the Carboniferous, nor do the glacial striæ or the alleged directions taken by the glaciers suggest it. It is most reasonable to assume that this area, located as it is close to Lake Superior, where during Huronian and Keweenawan or probably later times were vast volcanic eruptions, has been subject to repeated oscillations in level around a central area. That these oscillations have continued to more recent periods is shown by the uplifting, west of the longitude of Hamilton, of the Niagara escarpment with its face always away from, whilst the dip is towards, the central area of the State of Michigan or of Lake Huron, as well as by the depression and re-elevation of this whole area when the present superficial clays were laid down.

That the Niagara rocks did not extend much farther north of their present position near the southern coasts of Lake Ontario, nor much farther eastward than the escarpment between Lake Ontario and the Georgian Bay, is shown by the present general position and direction of these and the

underlying rocks to the immediate east, south and west of the lake, and the way in which they converge at the southern extremity of the Georgian Bay. A similar opinion may be ventured regarding the Medina sandstones. Prof. Bell, referring to Lake Ontario and certain other lakes, thinks that the glaciers descending from the higher grounds against the upturned edges of the softer rocks, tore them up rapidly, and carried away the debris, thus leaving the lake basins. The sharply defined edges of the escarpment, its generally bold face, and the comparatively short distance it has apparently receded, would, however, rather indicate in its case atmospheric effects, the wearing force of rivers, and the undermining action of waves upon an open lake or sea coast.

Sir William Logan, in the Geology of Canada, points out the resemblance of the Niagara escarpment, in places, to an ancient sea cliff. He also shows that it merely requires a depression of 442 feet to bring the ocean into Lake Ontario by way of the Hudson River and the Mohawk Valley, as well as by the St. Lawrence, and to inundate the whole of Central Ontario, although he did not then think that there was evidence that such an inroad had taken place. Such a depression would lead to the ocean penetrating as far west as the Niagara escarpment, and as far northward, in some places, as the Laurentian hills. The Georgian Bay would still be 140 feet above the ocean level, but if the thick deposits of sands, gravels and clays, between it and Lake Ontario, the positions of some of which are attributable to relatively very recent times, had not then existed, or were cut through at any point, the Georgian Bay would have been lowered to the ocean level, and have formed part of the same interior ocean as Lake Ontario. This would bring to the surface the presently submerged ridge between the Bruce peninsula and the Manitoulin Islands, owing to the lowering of Lakes Huron and Michigan to the level of the surface of the ridge. The outlet of these lakes would thereafter be over this ridge, and not by way of Lakes St. Clair and Erie. Now, the deep water cliffs on the eastern side of

the subaqueous ridge, between the Georgian Bay and Lake Huron, and those which are immediately beneath the escarpment of the Bruce peninsula, would seem to indicate that the waters of this bay have been at much lower levels than now to admit of the denuding action of waves and atmosphere on these subaqueous cliffs, and further, as already mentioned, that these cliffs formed the western boundary of a large and rapidly flowing pre-glacial river which, before the upheaval of the ridge between the Georgian Bay and Lake Ontario, connected these two basins, the denuding of the escarpment being due largely to it.

Without further here discussing the question of a connection between this bay and Lake Ontario, this fact is clear that at a period comparatively recent, and yet so far distant that the mammoth (*Euclephas Jacksoni*) then living, has since become extinct, the Niagara escarpment formed the western and southern boundary of a large interior fresh-water sea. The terraces and ridges around Lake Ontario show that this basin was considerably depressed or its outlet blocked, or that both causes intervened, raising the water to levels probably more than 400 feet higher than now. These terraces and ridges are found resting against the Niagara escarpment at Hamilton and Dundas, rising, Logan says, to a height of 318 feet, but they must in some cases be much higher there, as they nearly reach the summit of the escarpment along the line of the Grand Trunk railway; and whilst Bayfield mentions heights of 460 feet, Spencer gives the highest point on the summit near Hamilton as 516 feet. To the northward of Lake Ontario there are ridges of clay, sand or gravel, reaching varying heights. The summit on the Northern railway is attained at 755 feet above the lake, at twenty-six miles north from Toronto,[1] but the levels after falling nearly 300 feet, rise again at fifty-seven miles to 641 feet, passing first through a gravel ridge at fifty-three miles. Again, on the Toronto and Nipissing railway, the summit station is reached at 893 feet, at

[1] Spencer's Elevations in Canada.

twenty-seven miles back from the lake. Farther eastward on the Midland railway, in rear of Whitby, clay ridges are met with at twelve miles, attaining 649 feet, at fourteen miles 781 feet, and at thirty-three miles 674 feet. On the Port Hope section, further eastward, the heights are somewhat less. But let us not be led astray. Being so much higher than other ridges surrounding the lake, it is clear that the underlying Hudson River, Utica and Trenton strata, have been elevated during or since the deposition of these clays, sands and gravels, and in a direction roughly parallel with the lake. These superficial deposits obscure the strata, but this elevation, continued in a line towards Lake Huron, is noticeable on a greater scale at and beyond the townships, where it strikes the Niagara escarpment, whose summit near Dundalk station, on the Toronto, Grey and Bruce railway, has a height of 1,462 feet above Lake Ontario, and 1,127 feet above the Georgian Bay.

On the south side of Lake Ontario, where the subsequent elevation has been less than on the north side, an extended ridge of 188 feet has been thrown up. The American geologists have observed a gradual rise of 130 feet in this terrace, from the western end of Lake Ontario to Oneida Lake, and a rise of 170 feet more from Oneida Lake north to Jefferson County, beyond which it was not observed. This would imply a previous depression, increasing in depth with the south-easterly and easterly sides of Lake Ontario, and would show that its waters, now deeper towards the south-eastern end, were relatively more so in certain previous periods of the lake's history. The present levels have, as indicated, been largely influenced by the greater elevation on the northern than on the southern side, causing the waters to be thrown more towards the southern side.

At this period the outlet of the lake at the Thousand Islands was undoubtedly crossed by the Adirondack Mountains in a broad, rugged, irregular ridge, now partly depressed under the water to a maximum depth of about 250 feet. Some sand deposits occur towards Rockport, near Brockville, and in rear of Kingston, and may indicate the

eastern and western sides of the ridge, but this is, presently, mere conjecture. The height of the marine terraces on Montreal Mountain and elsewhere, as compared with the level of Lake Ontario, the absence of the Leda clays with their marine shells and fish farther west than Packenham, and the direction of the ice grooves which have a trend to the west of south on the Lake Ontario side, and, generally speaking, to the east of north or of south, on the St. Lawrence and Ottawa River sides, all tend to suggest this former higher altitude of the Laurentian ridge at the Thousand Islands. In this connection it may be noted that whilst it is usual to refer to the direction of the ice grooves as being either to the east or west of south, it is quite in consonance with the direction of the St. Lawrence Valley that these grooves should sometimes be referred to as having a course to the east of north.

With the elevation of the Niagara escarpment came the first record we have in the history of Lakes Ontario, Huron and Michigan as independent basins with the contours of to-day. Previous to and after this elevation, the present basins of these lakes were the seat of a great river system, with probably lake expansions smaller and different in outline from those now existing. Profs. Spencer and Claypole suggest that Lakes Ontario and Erie in part formed the valleys of a great pre-glacial river which, Spencer thinks, crossed from Lake Huron through the counties of Lambton, Middlesex and Elgin, and swerving around Long Point to the deepest portion of Lake Erie, trended thence northward to the Dundas Valley. Through this valley it entered the present basin of Lake Ontario, the line of deepest depression in which it formed by cutting down into the Hudson River shales, along the escarpment of which it flowed. There is much in the features of the lake floors and of the superficial deposits to support some such view, if more recent local warpings in the strata are considered. The great fracture in the strata at Dundas would give the required direction to the river there, and would be greatly enlarged by its eroding action. The outlet of this river by way of the Mohawk

Valley, is considered by some to be debatable ground, but it is difficult to now predicate what the levels were in the land surrounding these ancient rivers and seas. There have since been general changes in elevation extending over large areas, and there have also been local warpings within restricted areas which have completely altered within these areas the former levels in their relations to each other.

Prof. Spencer's view of this ancient river was limited to a connection between the southern end of Lake Huron and the eastern end of Lake Ontario by way of Port Stanley, Long Point and the Dundas Valley. It seems most probable, however, that the subaqueous escarpment which diagonally crosses Lake Huron from opposite Kincardine in the direction of the Straits of Mackinac, and which parallels the deepest depression there, may have been the south-western boundary of an npper section or expansion of this pre-glacial river valley. The hard Corniferous rocks would form an effective protecting side for such a river valley. Allusion has already been made to the probably earlier northward direction of this river in the line of depression toward Cape Hurd and over the subaqueous ridge there. The subaqueous river channels, already referred to, on each side of the Straits of Mackinac and in Whitefish Bay, in Lake Superior, also indicate higher sections of this preglacial river, and if the view be accepted that Lake Superior had its outlet in these older times across the upper peninsula of Michigan, it is most in consonance with facts that the waters of this great and ancient inland sea found their course to the ocean at, at least, one period of its history, by way of these broad rivers of Tertiary and antecedent times, though the St. Croix valley has, probably, at another time, also formed an outlet.

At what time, however, was this Niagara escarpment elevated? This is a question difficult of answer. And yet the facts already given would indicate that it was prior in time to the deposit of the clays, sands and gravels against the escarpment in the Dundas Valley, at the Bruce Peninsula and elsewhere; prior to the deposit of the

Artemesia gravels, which for long distances crown the summit of the escarpment parallel to its face, and are largely derived from its debris; prior to the elevation of the ridge or anticlinal which lies between Lake Huron and the Trent Valley, and gives to the escarpment its highest elevations above the lakes; prior to the Niagara Falls; and prior to the erosion which widened the fractures in the escarpment at the Dundas Valley and at the points of meeting of the waters of the Georgian Bay with those of Lake Huron proper, as well as the waters of Green Bay with those of Lake Michigan. On the other hand, this period of elevation of the escarpment was contemporaneous with the appearance in their present outlines of Grand Manitoulin, Cockburn and Drummond Islands in Lake Huron, and viewing all the facts was undoubtedly pre-glacial. Whilst the elevation of the escarpment gave in general terms the outlines of the basin of the three lakes, it is not to be inferred that these basins were at once filled with water to present levels. The country surrounding the lakes must have been higher than now to enable the pre-glacial river to cut the deep channels in Lakes Ontario and Huron which now exist.

Lakes Erie and St. Clair.

These two lakes have undoubtedly been within a very recent period more intimately united than now, and are probably the most recent in origin of the St. Lawrence Great Lakes. They lie in a Devonian basin with the Silurian rocks forming the portion of the rim of Lake Erie between Sandusky and Toledo. This basin is, however, overlaid with superficial deposits to such an extent that both lakes really fill shallow depressions on the surface of these deposits, and appear rather to be overflows caused by the restricted passage now of the waters over the Niagara escarpment in the one case, and through the Detroit River in the other, than to be due to physical forces which operating in past ages excavated preparatory basins.

Lake St. Clair has an average depth of about 12 feet and a maximum depth of 22 feet. The floor, except some limited areas of mud and clay in the centre, is overlaid everywhere with sand. The coast lines are low and often marshy, and, along the Canadian side fronting the counties of Essex and Kent, the land is barely elevated above the lake surface. The whole country here has quite the characteristics of the modern prairie, and its formation is unundoubtedly due to similar causes which are still in operation. Centuries of growth and decay of tall grasses, rushes and sedges in the extensive shallow marshes bordering the lake gradually contributed a black loamy soil which even now is not much above the level of Lake St. Clair. And not only has there been a more intimate connection with Lake Erie, but that the lake has at one time been somewhat deeper and is gradually filling up, is shown by the character of the deposits on its floor and by the extensive, progressive delta of the St. Clair River. The heavier sediments in the waters coming from Lake Huron have been depôsited in this lake, whilst the lighter silt appears to have been carried onwards towards and to Lake Erie.

The Detroit River, which now connects Lakes St. Clair and Erie, flows through a flat prairie-like country, but slightly elevated in most of its course above the water level. At the outlet of the river, on the Michigan side, extensive marshes prevail for some distance along the lake coast. The soil, however, is a fine yellow or drab-coloured silt containing minute grains of sand—the filterings no doubt from the coarser material deposited in Lake St. Clair.

For a lake of such wide area, Lake Erie is remarkably shallow. A line drawn from the City of Erie in Pennsylvania to Port Rowan, near Long Point, would have on its western side more than two-thirds of the lake area, and yet the maximum depth there does not exceed 84 feet. Again, a line from Pt. Pelée to Sandusky would form the eastern boundary of a large section, the greatest depth of which,

except in one isolated spot, is only 48 feet, and the average is only about 30 feet. Whilst thus shallow, the main body of the lake east of Pt. Pelée is remarkably level. The general depth is between 60 and 84 feet to within four or five miles of the shore on each side.

The deepest point in the lake lies in its eastern third about ten miles south-east of Long Point, and registers 210 feet. Here, parallel with the axis of the lake, there is a depression about twenty-seven miles in length by a width of from five to six miles, the depth everywhere in which exceeds 180 feet. Surrounding this and about forty miles long by twenty-five miles wide is an irregular area which has a minimum depth of 120 feet. This wider depression approaches within six miles of the south shore and thirty-five miles of Buffalo, towards which city it gradually shoals to 24 feet at the entrance to the Niagara River. The level plateau on which the main body of the lake rests is generally clay, whilst for the ten miles adjoining the United States side, the lake bottom is sand or sand and clay, with, occasionally, gravel, and, near the shore, rock. In the deeper parts off Long Point, which evidently included a wider area in preglacial times, the bottom is clay or mud. This is frequently replaced by sand towards the Niagara River, whilst near the shore there on both sides the bottom is rock.

The currents of the lake have, in the past, played an important part in shaping the contour of the Canadian side. The American coast line has a uniformity which the Canadian has not. The direction of these currents is seen in the outlines of Point Pelée, Rondeau Harbour and Long Point and in the arched contour of the long coast line fronting the County of Elgin, whose high clay cliffs have been worn gradually backward through great distances to their present position by the eroding action of waves, frosts and rains, and have supplied material for shallowing the lake in front and building up Long Point. This process is still going on. Within the barriers created by Point Pelée, Rondeau Harbour and Long Point it is, however, being

supplemented by the shallows becoming marshes which in time will fill up with mould arising from the annual growth and decay of the reeds, rushes and grasses which flourish in profusion there.

Leaving out of view the above subsequent changes in parts of its area, Lake Erie probably dates the outlining in a general way of its present limits back to the time when the Ontario Lake ridges were being formed, and when the clays and gravels were being piled up against the Niagara escarpment and had blocked the Dundas valley. The entire Ontario peninsula had been under water for a long period, and by the deposition of the clays over it, the courses of the pre-glacial rivers had been partly filled up. The united lakes, as their terraces show, had at first a high level, and their waters found here, as Newberry has shown, outlets to the southward through the gaps furnished by the river valleys in Ohio. On the elevation of the land, new drainage channels had to be cut by the water. It was then that the outflow from Lake Huron began by the St. Clair and Detroit Rivers and of Lake Erie by the Niagara River, the channels of the old glacial river having been blocked and the waters being kept back, not merely by the superficial deposits, but probably by warpings of the strata beneath as well. It may be that the lake level was at first retained at a higher point than now, the escarpment at Lewiston being 38 feet above Lake Erie. This would have prevented a separation then between that lake and Lake Huron. It is most probable, however, that the Niagara did not fall over the escarpment at Lewiston but found at this point, as at St. David's, a great fracture in the cliff, affording it a natural gorge down which its waters ran, and which they gradually further eroded. Other such fractures are found in the escarpment both south of Lake Ontario and between it and the Georgian Bay, some of them forming great ravines several miles in length, and presently, in some cases, the beds of streams. Such fractures were a necessary consequence of the elevation of the escarpment and of the directions which this elevation followed.

Conclusions.

In summing up the conclusions of this paper it may be said :

That glaciers, whilst contributing some results, had not much effect in eroding the lake basins proper, or in shaping the present general outlines.

That the superficial deposits are the accumulations of denudation during immense periods of time since the Carboniferous and earlier eras, and are not to be specially credited to the operation of glaciers.

That Lake Superior is the most ancient of the lakes, dating its origin as far back as Cambrian, Keweenawan and Huronian times; that it is, in part at least, a synclinal trough, that volcanic action has had most to do with its origin and the shaping of its coasts; that its early outlet was through the depression in Whitefish Bay and that its waters joined the great pre-glacial river system at or near the Straits of Mackinac.

That Lakes Michigan, Huron and Ontario were originally the bed of a pre-glacial river which first crossed the Ontario peninsula along the Niagara escarpment, and afterwards was diverted to a course by way of Long Point, on Lake Erie and the Dundas valley; that their basins were largely defined by the elevation of the Niagara and Hudson River escarpments, and in more recent times by warping of the strata and deposit of superficial sands and clays which blocked the old river channels and resulted in the lake basins retaining their water on the final elevation of the land to its present general levels.

That the pre-glacial river system expanded in time into smaller lakes in each of the present basins of Lakes Michigan, Huron, Erie and Ontario.

That Lakes Erie and St. Clair are the most recent of the lakes, and have at one time been more closely united, and that the formation of this united lake was due to the blocking of the old outlets both by superficial deposits and warping of the strata, and to the water being thus retained

in the basin on the final elevation of the land to the levels of to-day.

That great fractures at or near the outcrops of the strata occasioned by the directions of the forces which elevated the strata, originated, in many instances, the deep bays and inlets which indent the Niagara and Hudson River escarpments and rocky coast lines of Lakes Michigan and Huron, these effects being afterwards supplemented by the action of waves, currents, atmospheric causes and probably local glaciers.

That since the elevation of the land to the levels of to-day, the action of waves and currents on the clay cliffs and sand deposits has, in many places, greatly rounded off the general outlines of the coast, and the material from this and other sources has been spread over the lakes, or has served to create new features in the coast line elsewhere.

Note on Balanus Hameri in the Pleistocene at Rivière Beaudette, and on the Occurrence of Peculiar Varieties of Mya arenaria and M. truncata in the Modern Sea and in the Pleistocene.

By Sir William Dawson, LL.D., F.R.S.

(1.) *Balanus Hamon.*

The fine species of Balanus above named, which is still living in somewhat deep water on our coasts, was first described as a Pleistocene fossil of Canada by Sir C. Lyell in his paper on "Fossils and Recent Shells collected by Capt. Bayfield."[1] Bayfield found it in the Pleistocene at Beauport, near Quebec. It was subsequently found by me in the Pleistocene at Rivière du Loup, St. Nicholas, and Montreal.[2] From the loose attachment of its radial plates, it is

[1] Philos. Trans. 1859.

[2] "Notes on Post Pliocene of Canada." Canad. Nat. 1872.

usually found in fragments, but entire specimens occur attached to stones and boulders at R. du Loup.

B. Hameri is at present extensively distributed as a living species in the North Atlantic and the Arctic Sea. I have specimens collected by Mr. A. Downes of Halifax, Nova Scotia, in a living state, near Halifax harbour. As a Pleistocene fossil, it occurs at Uddevalla in Sweden, and was named by Linnaeus *Balanus Uddevalensis*. The name *B. Hameri*, given by Ascanius in 1767, is that now recognized. It has also been found in Pleistocene clays in Greenland (Spengler), and in the Pleistocene of Russia (Murchison).

The specimens now under consideration are interesting, as being found farther west than previously; River Beaudette being on the line of the Grand Trunk Railway, 34 miles west of Montreal, and the locality being near its entrance into Lake St. Francis. They are also interesting from their remarkable perfection and the large masses which they form, some of which contain as many as a dozen individuals attached to each other. The specimens were collected by Mr. A. W. McNown, of Rivière Beaudette, and by Mr. Stanton, C.E., of Lancaster, and much credit is due to these gentlemen for their care in collecting and preserving these interesting fossils.

The animals seem to have been covered, when living, with an irruption of sand, for the opercular valves of many of them are still in place, and owing to a slight infiltration of calcareous matter, the radial plates and opercular valves have been cemented together, which accounts for their perfect preservation. It is to be observed, however, that the sheils of Balani are composed of a remarkably dense and indestructible calcium carbonate, much less perishable than the shells of most mollusks.

The original attachments of the animals, so far as observed, have been on pebbles on the surface of clay, and as these afforded space only for one or two individuals, the young were obliged to attach themselves to the old in successive generations, forming most grotesque groups, which still remain entire.

In the same deposits were found shells of *Saxicava Arctica. Tellina (Macoma) Groenlandica* and *Mya arenaria* of a small variety. These shells would indicate cold and not very deep water; and although *B. Hameri* is at present a deep-water species, it is probable that in cold water it lives, like some other species, nearer the surface than in the warmer seas.

The specimens were found in an excavation near the railway, and so far as appears from the descriptions, in beds which belong to the top of the Leda clay and base of the Saxicava sand, a position which is usually the most productive part of our Pleistocene deposits in fossil shells.

From a note and sketch kindly furnished to me by Mr. Stanton, it appears that the shells occur about 27 feet below the surface, and about 11 feet above the level of Lake St. Francis. The containing beds are clay and sand, and above these are alternations of clay, sand and gravel, the top being gravel, with boulders immediately under the surface soil. The position of the shells would thus appear to be in what I have called the Upper Leda clay, or the base of the Saxicava sand, and under the newer gravel and boulder deposit which often caps the latter.

(2.) *Species of Mya, and Varietal Forms.*

In my Notes on the Post Pliocene of Canada,[1] I have remarked on the small size, peculiar forms and comparative rarity of *Mya arenaria* in the Pleistocene, as compared with the modern Gulf and River St. Lawrence, and on the abundance of *Mya truncata*, and especially of the short variety (*M. Uddevalensie*), while *Mya truncata* is comparatively rare in the modern waters of our coast, and the short variety especially so. I had last summer an opportunity at Little Metis to see both species and their different varieties living together in such a manner as to illustrate better the causes of the difference of the Pleistocene forms.

At the head of Little Metis Bay, where the water is shal-

[1] Canadian Naturalist, 1872.

low and warm, and the bottom is soft mud and sand, a large variety of *Mya arenaria* is very plentiful in the flats bare at low tide; so much so that the place is resorted to by fishermen from localities lower on the coast for bait. It sometimes attains the length of 4½ inches, and has a thick, dense shell, without perceptible epidermis, and often with radiating bands. So far as I am aware, neither *Mya truncata* nor the peculiar variety of *M. arenaria* referred to below, occurs on this part of the coast.

I have not infrequently dredged *Mya truncata*, usually the long variety, but sometimes the short Uddevalensis variety, in deep water outside the bay, but have not seen it above low-water mark, though it occurs not far from this line; and, on the opposite side of the River St. Lawrence, I have found it at Tadoussac, where the water is still colder, close to low-water mark. I was not aware that *Mya arenaria* occurred on the comparatively steep and stony shore outside the bay, and it is certainly not found there inside of the low-water limit.

Last summer, however, after a heavy easterly gale, great numbers of *Mya arenaria*, in a living state, and a few specimens of *M. truncata*, were thrown up on the beach, and must have been derived from the mud disturbed by the breakers at no great distance outside of low-water mark, or on a slight bank a little further seaward. These shells were all of small or moderate size, somewhat round and flat in form, much wrinkled and covered with a thick brown epidermis which extended a little way beyond the posterior end of the shell, which was, however, rounded and not truncated, and destitute of the corneous tube of *M. truncata*. Still, many of the specimens might, at first sight have been mistaken for *M. truncata*, with the tube partly broken off. This enabled me, for the first time, to understand the remark of Fabricius, that in Greenland the two species are so similar, that but for the hinge and the tube they might be confounded. With these were thrown up specimens of *M. truncata*, which must have lived with the others, the inner limit of *M. truncata* probably overlap-

ping the outer limit of *M. arenaria.* The short or Uddevalensis variety of truncata was, however, very rare, only a few shells in a perfectly recent state having been found, and they probably lived in somewhat deeper and colder water than the others. The water, I may add, on this coast is so far affected by the Arctic current as to be quite cold, except near the shore and in shallow bays, and the species dredged in 10 to 15 fathoms are, in general, similar to those of the Labrador coast, belonging rather to the boreal than to the Acadian fauna. With the Myas were cast up shells of *Solen ensis*, var. *Americanus* of Carpenter, and of *Machaera Costata*, the latter sometimes of large size, though it is more abundant in the warmer water at the head of the bay, where *Purpura Lapillus*, a rare shell on this coast, also occurs on the reefs.

It is evident that though there is no passage from one species into the other, the long variety of *Mya truncata* represents the extreme limit of modification of that species for a shallow and warm-water habitat, while the small epidermis-clad variety of *M. arenaria* represents its extreme modification for deeper and colder water than usual; and along the coast at Metis these two varieties meet.

The coldness of the Pleistocene seas thus explains the occurrence, in the Upper Leda clay, of the peculiar small and epidermis-clad variety of *M. arenario* and of the short form of *Mya truncata*. The conditions in the colder parts of the River St. Lawrence approach in these respects to those of the Pleistocene, though they are no doubt more fully realized in the Arctic seas.

As I have remarked in my notes on the Post Pliocene, the brown wrinkled epidermis-clad variety of *M. arenaria* occurs plentifully along with *M. Uddevalensis* in the Upper Leda clay at Rivière du Loup.

From the accounts of Arctic collectors from Fabricius downwards, it would appear that in Greenland, as in Pleistocene Canada, *M. truncata* is very abundant, and occurs at low water in the sands, as *M. arenaria* does further south. It would seem also that it forms a large part of the food of

the walrus and other animals, and is much used by the inhabitants. It also appears that a small variety of *M. arenaria*, with brown epidermis, is most common in Greenland, and occurs with *Mya truncata*, which is, however, more plentiful. The description given by Fabricius of *M. arenaria* obviously agrees with that of my small and brown variety from Metis.

It is interesting to note the companionship of these allied species in the North Atlantic throughout the Pleistocene and Modern periods, and their range of varietal forms applicable to each, according to the conditions to which they they have been exposed, along with their continued specific distinctness, and the preference of each for certain kinds of environment, so that in some places one, and in others the other, predominates, while this relative predominance, as well as the prevalence of certain varietal forms, might no doubt be reversed by change of climate or of depth.

On Modern Concretions from the St. Lawrence.

By Rev. Prof. Kavanagh, S. J.

With Remarks on Cylinders found in the Potsdam Sandstone.

The modern concretions referred to were collected on the the rush-covered shores of the St. Lawrence near Boucherville, and may be thus described :—

They resemble small radishes, like these, varying much in shape, are symmetrical, perforated axially, the more or less perfect bore or perforation often containing vegetable fibres.

Their production seems to be due to the action of the rush roots upon the soft, plastic clay, so indurating it that it can resist the wash of the waves; the receding of the water during the summer leaves these concretions standing out in relief, like fossils on a weathered surface.

The phenomenon seems to be analogous to that formation of nodules around organic nuclei within masses of soft material, which occurs in many geological formations.

These little bodies are evidently clay concretions formed around vegetable fibres, and hardened by a small percentage of calcium carbonate, since when treated with hydrochloric acid they effervesce feebly and become disintegrated. They probably originate in the molecular aggregation of the calcareous matter in the clay around any foreign body included in it. They are about half an inch in diameter, and the largest may have been two inches in length, with ronnded ends. When broken, they show a small central canal containing a little sand and strips of epidermal tissue, the remains of a root or stem. One shows three branches apparently proceeding in a verticillate manner from a central stem. In the centre, the light, reddish-brown colour of the clay has assumed a greenish hue, owing to deoxidation of the Peroxide of Iron by decay of the vegetable nucleus.

Remarks by the President on Certain Ancient Concretions, in Connection with the Above.

On a small scale these modern concretions are similar to those so often found to enclose vegetable remains in the carboniferous system; and in the Pleistocene at Green's Creek, on the Ottawa, vegetable stems are sometimes found enclosed in similar, but larger and harder concretions.

Concretions of this kind appear to throw light on those remarkable trunk-like cylinders which have been found in the Potsdam sandstone. These attracted the attention of Sir Wm. Logan many years ago; but as they showed no structure, external markings, or carbonaceous matter, they were not regarded by him as true fossils. More recently they have been studied by Dr. Selwyn in exposures on the bank of the Rideau canal, near Kingston. Dr. Selwyn has kindly sent photographs of these specimens, to be exhibited to the Society. Mr. A. Young, a student in applied science in McGill University, has also presented fine specimens to the

Peter Redpath Museum, one of which is on the table. In their entirely arenaceous character, their concentric lines of growth, as well as in traces of a central axis or canal of small dimensions, and, in one instance, in a regularly rounded end, they resemble concretions, but I have been unable to find any central organic matter. This may, however, have perished, leaving a mere cavity, as in the modern concretions above described, which would become filled with sand, like that of the enclosing cylinder. This at least appears to me at present the most probable explanation of these puzzling forms. It would be confirmed if any distinct vegetable or zophytic axis could be found in any of the specimens, or any carbonaceous matter representing such an axis. In the meantime, it may be regarded as a more or less probable conjecture as to their origin.

The Influence of the Nervous System on Cell Life (Metabolism).*

By T. Wesley Mills, M.A., M.D., Professor of Physiology, McGill University, Montreal.

In a paper entitled "A Physiological Basis for an Improved Cardiac Pathology," read in abstract in August, 1887, before the Canada Medical Association, I endeavoured to show the relation of the cardiac nerves to the nutrition of the heart; but the subject grew as I proceeded with its study, so that I perceived that the theory I applied to the heart was equally true of the other organs and tissues. In that paper, which was published in the New York *Medical Record* of October 22nd, 1887, I advanced a large number of facts derived from common experience, physiological experiment, pathology, and clinical medicine, in favor of what I termed a theory of *constant neuro-trophic influence.*

* Read before the section in Physiology of the Congress of American Physicians and Surgeons, at its first annual meeting, September, 1888.

Briefly this theory was to the effect that in mammals, if not also in some lower groups of vertebrates, the nutritive processes are all under a *constant* regulative influence by the nervous system, in the sense that they are so dependent upon this influence, that they do not, and would not, go on without it. It was also pointed out that function was not a thing totally distinct and alone regulated by the nervous system, but that function was only one *phase* of a general metabolism, and was no more under the influence of the nervous centres than the other less recognized phases.

A year's additional study of the subject has convinced me more than ever of the necessity of widening our views of the relation of the various organic processes, so that instead of terming the theory, I would offer for your consideration one setting forth a constant neuro-trophic influence, I would replace it by the expression *constant neuro-metabolic influence,* as it implies a wider and truer conception of the subject, as I view it; and I am not sure but that it would be well to abandon the term "nutrition" altogether, or, if not, certainly to define it afresh.

The following, then, is a brief presentation of the subject in a form largely free from technicalities.

This subject is of the utmost importance, and has not received the attention hitherto in works on physiology to which we believe it is entitled. We may first mention a number facts on which to base conclusions :—

1. Section of the nerves of bones is said to be followed by a diminution of their constituents, indicating an alteration in their metabolism.
2. Section of the nerves supplying a cock's comb interferes with the growth of that appendage.
3. Section of the spermatic nerve is followed by degeneration of the testicle.
4. After injury to a nerve, or its centre in the brain or spinal cord, certain affections of the skin may appear in regions corresponding to the distribution of that nerve, thus, *herpes zoster* is an eruption that follows frequently the distribution of the intercostal nerve.

5. When the motor cells of the anterior horn of the spinal cord, or certain cells in the pons, medulla, or crus cerebri, are disordered, there is a form of muscular atrophy which has been termed "active," inasmuch as the muscle does not waste merely, but the dwindling is accompanied by proliferation of the muscle nuclei.
6. In *acute decubitus*, bed sores form within a few hours or days of the appearance of the cerebral or spinal lesion, and this with every precaution to prevent pressure, or the other conditions that favor the formation of such sores.
7. After section of both vagi, death results after a period varying in time, as do also the symptoms, with the animal.

In some animals pneumonia seems to account for death, since it is found that if this disease be prevented, life may at all events be greatly prolonged.

The pneumonia has been attributed to paralyses of the muscles of the larynx, together with loss of sensibility of the larynx, trachea, bronchi,and the lungs, so that the glottis is not closed during deglutition, and the food finding its way into the lungs has excited the disease by irritation. The possibility of vaso-motor changes is not to be overlooked. In birds, death may be subsequent to pneumonia or to inanition from paralysis of the œsophagus, food not being swallowed. It is noticed that in these creatures there is fatty (and sometimes other) degeneration of the *heart*, liver, stomach and muscles.

8. Section of the trigeminus nerve within the skull has led to disease of the corresponding eye. This operation renders the whole eye insensible, so that the presence of offending bodies is not recognized, and it has been both asserted and denied that protection of the eye from such irritation prevents the destructive inflammation.

With the loss of sensibility there is also vaso-motor paralysis; the intra-ocular tension is diminished, and the relations of the nutritive lymph to the ocular tissues is altered. But all disturbances of the eye, in which there are vaso-motor alterations, are not followed by degenerative changes.

9. Degeneration of the salivary glands follows section of their nerves.
10. After suture of long-divided nerves, indolent ulcers have been known to heal with great rapidity.

This last fact, especially, calls for explanation. It will be observed, when one comes to examine nearly all such instances as those referred to above, that they are complex. Undoubtedly, in such a case as the trigeminus or the vagi, many factors contribute to the destructive issue, but the fact that many symptoms and lesions are concomitants does not of itself negative the view that there may be lesions directly dependent on the absence of the functional influence of nerve fibres over the metabolism.

We prefer, however, to discuss the subject on a broader basis, and to found opinions on a wider survey of the facts of physiology.

After a little time (a few hours), when the nerves of the submaxillary gland have been divided, a flow of saliva begins, and is continuous till the secreting cells become altered in a way visible by the microscope.

Now, we have learned that protoplasm can discharge all its functions in the lowest forms of animals and in plants, independently of nerves altogether.

What, then, is the explanation of this so-called "paralytic secretion" of saliva? The evidence that the various functions of the body, as a whole, are discharged as individual acts, or series of acts, correlated to other functions, has been abundantly shown; and looking at the matter closely, it must seem unreasonsble to suppose that this would be the the case if there was not a close supervision by the nervous system over even the details of the processes. We should ask that the contrarv be proved rather than that the burthen of proof should rest on the other side. Let us assume that such is the case; that the entire behavior of every cell of the body is directly or indirectly controlled by the nervous system in the higher animals, especially mammals, and ask, What facts, if any, are opposed to such a view?

We must suppose that a secretory cell is one that has been,

in the course of evolution, specialized for this end. Whatever may have been the case with protoplasm in its unspecialized form, it has been shown that gland cells can secrete independently of blood supply, when the nerves going to the gland are stimulated. Now, if these cells have learned, in the course of evolution, to secrete, then, in order that they shall remain natural—not degenerate—they must, of necessity, secrete, which means that they must be the subject of a series of metabolic processes, the final of which only is expulsion of formed products. Too much attention was at one time directed to the latter. It was forgotten, or rather, perhaps, unknown, that the so-called "secretion" was only the last of a long series of acts of the cell. True, when the cells are left to themselves, when no influences reach them from the stimulating nervous centres, their metabolism does not at once cease. As we view it, they *revert* to an original ancestral state when they performed their work, lived their peculiar individual life as less specialized forms, wholly or partially independent of a nervous system. But such divorced cells fail; they do not produce normal saliva; their molecular condition goes wrong at once, and this is soon followed by departures visible by means of the microscope. But just as secretion is usually accompanied by excess of blood, so most functional conditions, if not all, demand an unusual supply of pabulum. This is, however, no more a cause of the functional condition than food is a cause of a man's working. It may hamper if not digested and assimilated.

It becomes, then, apparent that the essential for metabolism is a vital connection with the dominant nervous system.

It has been objected that the nervous system has a metabolism of its own, independent of other regulative influence, but in this objection it seems to be forgotten that the nervous system is itself made up of parts which are related as higher and lower, or, at all events, which intercommunicate and energize one another.

We have learned that one muscle cell has power to rouse

another to activity, when an impulse has reached it from a nervous centre.

Doubtless this phenomenon has many parallels in the body, and explains how remotely a nervous centre may exert its power. It enables one to understand, to some extent, many of those wonderful co-ordinations (obscure in detail) which are constantly taking place in the body.

We think the facts, as they accumulate, will more and more show, as has been already urged, that the influence of blood pressure on the matabolic (nutritive) processes has been much over-estimated. They are not essential, but concomitant in the highest animals.

Turning to the case of muscle, we find that when a skeletal muscle is tetanized, the essential chemical and electrical phenomena are to be regarded as changes differing in degree only from those of the so-called resting state.

There is more oxygen used, more carbonic anhydride excreted, etc. The change in form seems to be the least important from a physiological point of view. Now, while all this can go on in the absence of blood, or even of oxygen, it cannot take place without nerve influence or something simulating it.

Cut the nerve of a muscle, and it undergoes fatty degeneration and atrophy. True, this may be deferred, but not indefinitely, by the use of electricity, acting somewhat like a nerve itself, and inducing the approximately normal series of metabolic changes. If, then, the condition when not in contraction (rest) differs from the latter in all the essential metabolic changes in rate or degree only, and if the functional condition or accelerated metabolism is dependent on nerve influence, it seems reasonable to believe that in the resting condition the latter is not withheld.

Certain forms of paralysis (*e. g.*, hysterical) are not followed by atrophy. Why? Because in this form the metabolic nerve influence is still exerted.

The recent investigations on the heart make such views as we are urging clearer still. It is known that section of the vagi leads to degeneration of the cardiac structure. We

now know that this nerve contains fibres which have a diverse action on the metabolism of the heart, and that according as the one or the other set is stimulated, so does the electrical condition vary; and everywhere, so far as known, a difference in electrical condition seems to be associated with a difference in metabolism, which may be one of degree only, perhaps, in many instances, still a difference. The facts, as brought to light by experimental stimulation, harmonize with the facts of degeneration by the cardiac tissue on section of the vagi; but this is only clear on the view we are now presenting that the action of the nervous system is not only universal, but that it is *constant*; that function is not an isolated and independent condition of an organ or tissue, but a part of a long series of metabolic changes. It is true that one or more of such changes may be arrested just as all of them may go on at a less rate, thus, actual outpouring of pancreatic secretion is not constant; but secretion is not summed up in discharge merely, and on the other hand it would seem that in some animals the granules of the digestive glands are being renewed while they are being used up in secreting cells. The processes may be simultaneous or successive. Nor do we wish to imply that the nervous system merely holds in check, or, in a very general sense, co-ordinates processes that go on unoriginated by it. We think the facts warrant the view that they are in the highest mammals, either directly (most) or indirectly originated by it; that they would not take place in the absence of this constant nervous influence.

The facts of common observation, as well as the facts of disease, point in the strongest way to such a conclusion.

Everyone has experienced the influence on, not one, but many, functions of the body, we might say the entire metabolism of depressing or exalting emotions. The failure of appetite, loss of flesh and mental power under the influence of grief or worry, tell a plain story. Such broad facts are of infinitely more value in settling such a question as that now discussed than any *single* experiment.

The best test of any theory is the extent to which it will

explain the whole round of facts. Take another instance of the influence over metabolism of the nervous system.

Every athlete knows that he may overstrain, *i. e.*, he may use his muscles so much as to disturb the balance of his powers somewhere, very frequently his digestion, but often there seems to be a general break—the whole metabolism of the body seems to be out of gear. If we assume a constant nervous influence over the metabolic processes, this is comprehensible. The centres can produce so much only of what we may call nervous force, using the term in the sense of directive power, and if this be unduly diverted to the muscles, other parts must suffer. The same holds of excessive mental application.

On this view, also, the value of rest or change of occupation becomes clear. The nervous centres are not without some resemblance to a battery; at most the latter can generate only a definite quantity of electricity, and if a portion of this be diverted along one conductor, less must remain to pass by any other.

It is of practical importance to recognize that, under great excitement, unusual discharges from a nerve centre may lead to unwonted functional activity; thus, under the stimulus of the occasion, a man may in a boat-race originate muscular contractions he could not by the strongest efforts of his will cause under other circumstances. Such are always dangerous. We might speak of a reserve or residual nerve force, the expenditure of which results in serious disability. It also applies to mental and emotional effects, as well as muscular, and seems to us to throw light upon many of the failures and successes (so-called) of life.

It seems that our past views of secretion and nutrition have been partial rather than erroneous in themselves, and it is a question whether it would not be well to substitute some other terms for them, or, at least, to recognize them more clearly as phases of a universal metabolism. We appear to be warranted in making a wider generalization.

To regard processes concerned in building up a tissue, as apart from those that are recognized as constituting its

function, seems to be illogical and unwise, with the knowledge we at present possess.

Whether, in the course of evolution, certain nerves, or, as seems more likely, certain nerve fibres in the body of nerve trunks have become the medium of impulses that are restricted to regulating certain phases of metabolism, as, *e. g.*. expulsion of formed products in gland cells, is not, from a general point of view, improbable, and is a fitting subject for further investigation. But it will be seen that we should regard all nerves as "trophic," in the wider sense. What is most needed, apparently, is a more just estimation of the relative parts played by blood and blood-pressure, and the direct influence of the nervous system on the life-work of the cell.

These views are greatly strengthened by the facts well known to every observer of disease in the human subject. The preponderating development of the cerebrum in man must be taken into account in the working of every organ. To have a normal stomach, liver, kidneys, etc., is not enough; for real health, all the parts of that great complex of organs we call the brain must not only work, but work in concert. We must regard the nervous centres as the source of ceaseless impulses that operate upon all parts originating and controlling the entire metabolism, of which what we term functions are but certain phases, parts of a whole, but essential for the health or normal condition of the tissues.

Against such a view we know no facts, either of the healthy or disordered organism.

On the Classification of the Cambrian Rocks in Acadia.

No. 2.

By G. F. Matthew, M.A., F.R.S.C.

1. *Comparison of Species with Description of a new Species of Obolus.*

When in Vol. III, No. 2, of this journal, the writer suggested a provisional arrangement of the members of the Cambrian System in Acadia, he did not anticipate that the doubt then resting upon the proper position of the Olenellus beds, (or Georgian Series), would so soon be removed.

Early in the past summer, he received from Dr. F. Schmidt, of St. Petersburg, his pamphlet "On a newly discovered Lower Cambrian fauna in Eastland," wherein is described, under the name of *Olenellus Mickwitzi*, a trilobite in all respects similar, in generic characters, to Mr. C. D. Walcott's *Mesonacis*. This trilobite is found in company with *Mickwitzia monilifera* (=*Lingula* (?) *monilifera*, Linrs.) a brachiopod of the Eophyton Sandstone. The Eophyton Sandstone is at the base of the Cambrian System in Sweden, below the Paradoxides bed, and this trilobite (*O. Mickwitzi*), therefore, is of greater antiquity than Paradoxides. This view of the comparative age of the Paradoxides beds is supported by the discovery (communicated to me by Mr. Walcott) of *Ollenelus* (?) *Kjerulfi* in the Cambrian beds of the State of New York. This species is well-known as being below the Paradoxides beds in Europe.

So there was, in the discovery of these two species in the situations designated, sufficient evidence to show that the Olenellus beds, or those containing the Georgian fauna, were below the Paradoxides, and not above, as I suggested in my former paper to be the more probable alternative.

Mr. Walcott has since made the position of these beds certain by visiting Newfoundland, and examining the district where, many years ago, Mr. A. Murray found the Georgian

fauna in this relation: although it was not recognized by him as such, because, neither the assemblage of species collected by Mr. Murray, and determined by Mr. Billings, nor those of Georgia, Vt., had been sufficiently compared to show that they were of one fauna. Mr. Walcott states that this fauna is unquestionably beneath the Paradoxides beds in Newfoundland, at a depth of about 200 feet. There can be, therefore, no longer any doubt that the Olenellus-Doryphyge phase of the Olenellus fauna, which is the Olenellus fauna of Eastern North America, is older than the Paradoxides beds of the same region.

Though this fauna is found north, east, and west of New Brunswick, having been recognized in Quebec, Cape Breton, and Massachusetts, it has not been found in the first named Province, notwithstanding that there are there no less than 1,600 feet of Cambrian measures beneath the Paradoxides beds. But, though this fauna has not been found in New Brunswick, the writer proposes to point out where, from our present knowledge of the subject, it is likely to be found.

There is, in all the Cambrian basins of this Province, just beneath the oldest beds in which the Paradoxides are known to occur, a peculiar bed of shales, of considerable thickness, which, though apparently no coarser or harder than the beds below it, stands out in the sections with peculiar massiveness, and on examination is seen to be cut in all directions by the burrows of large marine worms. Here the brachiopods lie at all angles in the shale, and in the worm-burrows, as though the worms, in their search for food, had disturbed all the successive layers of the sea-bottom, and kneaded the mud into a continuous pasty mass.

This bed is at the top of Band *b*., and marks the close of a period of disturbed physical conditions, that ushered in the tranquil time of the Paradoxides. In and below this bed, the remains of trilobites are rare; and except as regards the brachiopods, the known fauna differs entirely from that in the beds above. In the middle of Band *b*., we have been able to recognize an *Agraulos*, and at the base an

Ellipsocephalus, both recalling forms which, in Europe, are associated with *Olenellus* (?) *Kjerulfi.*

In the most northerly basin of Cambrian Rocks, in the southern part of this Province, (New Brunswick), the writer, during the past summer, collected an *Obolus* near the base of Band *b.*, which may serve to link the fauna of this band with that of the Fucoid Sandstone, in Sweden. The shell in question is remarkable for the change in form which it underwent during growth, and for a peculiar radular ornamentation.

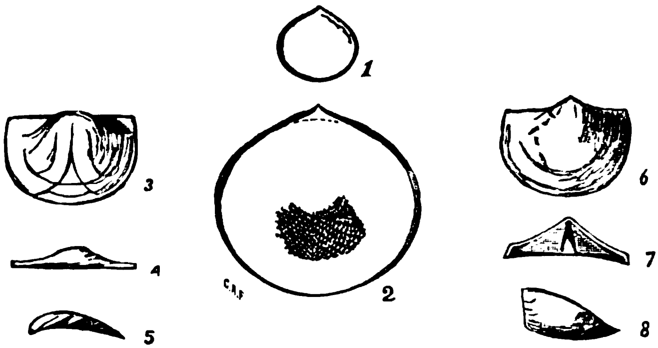
This variety of sculpture is not infrequent in the brachiopods, which are found in company with the Olenelloid trilobites. Such a form is known in the Fucoidal Sandstone, under the name of *Lingula* (?) *favosa* Linrs. Another similar one is *Lingulella cœlata*, Hall, and a third is *Kutorgina pannula*, White, of the Olenellus fauna of Nevada.

Dr. Hicks also figures and describes an organism from the Caerfai Group in Wales, as a doubtful Leperditia (*L.* ? *Cambrensis*) which may be a brachiopod with cancellated ornamentation, it is represented as of oval or semi-circular form, and is said to show a "reticulate ornamentation.[1] Possibly this, which is found in sandy beds with Ligulella, may alse be a brachiopod, with radular sculpture, but on the other hand it may be a fragment of a Olenelloid trilobite, as in this sub-family the surface has reticulate ornamentation.

Kutorgina pannula is a similar, but smaller form, in which the cancellation is raised as in some examples of our Obolus; and the possible outgrowths of the latter form may be seen by comparing its embryonic shell with *Kutorgina pannula.*

The following are the characters of the Obolus referred to above:—

[1] Quart. Jour. Geol. Soc., London, 1871, Vol. 27, p. 401.



OBOLUS PULCHER, n. sp.

Fig. 1. Ventral valve. Natural size.
" 2. Same, mag. 2½, to show the surface markings. The dotted line near the top of the figure indicates the outline of the dorsal valve at that part.
Fig. 3. Embryonic shell, Dorsal valve, mag. $\frac{15}{1}$.
" 4. Same, seen from behind.
" 5. Same, seen from the side.
" 6. Embryonic shell, Ventral valve, mag. $\frac{15}{1}$.
" 7. Same, seen from behind.[1]
" 8. Same, seen from the side.

General outline nearly orbicular; the valves gently, but rather flatly and evenly arched down from the centre all around, except that the dorsal is flatter at the back than elsewhere, and the ventral valve runs out into a short acuminate umbo.

Dorsal valve somewhat wider than long; more strongly arched towards the front than elsewhere; somewhat elevated at each end of the hinge line.

Ventral valve about as wide as long, sides and front evenly rounded; back produced into a short pointed beak, angle of incidence of the two sides, 110° to 120°.

Sculpture of the posterior half of the valves, consisting of minute tubercles, sloping forward, and arranged in rows, which arch forward across the mesian line from each late-

[1] The angle at each side is an error of the engraver.

ral margin, giving to the surface a cancellated appearance. In a few examples, the tubercles are connected, so as to give the surface a pitted appearance, like that of *Lingula*(?) *favosa* and *Kutorgina pannula*.

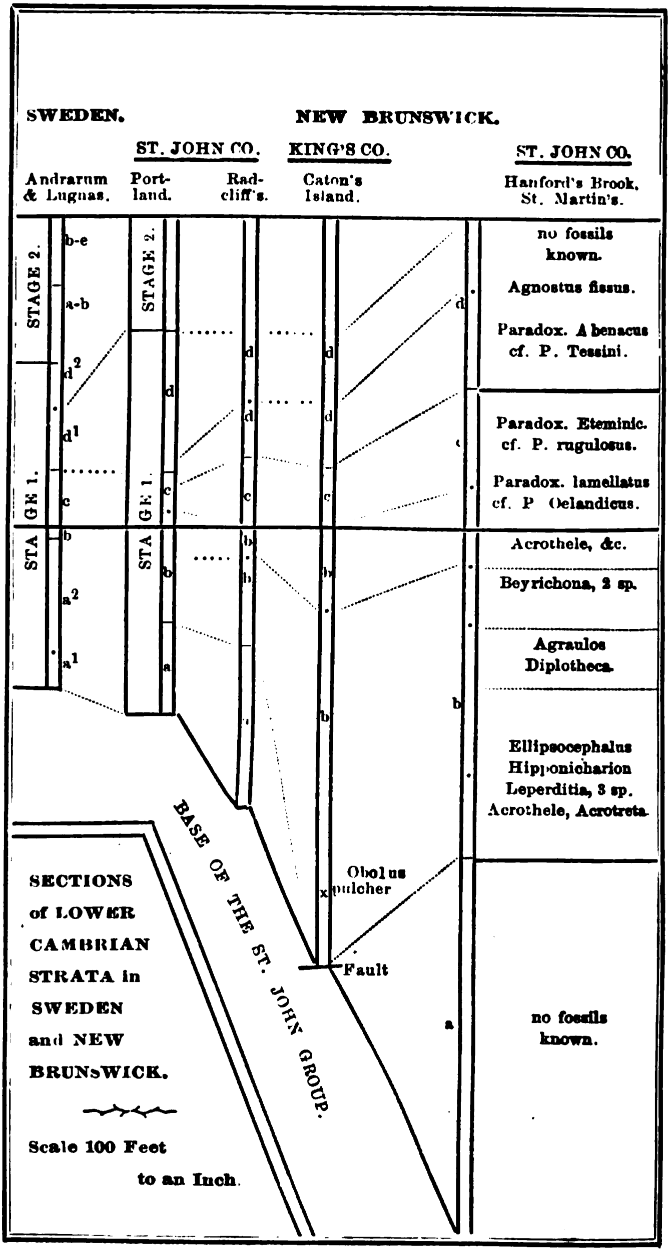
Sculpture of the anterior part on the front and sides in the adult consisting of concentric lines of growth, with faint, interrupted, radiating striæe.

2. *Comparison of Sections in Sweden and New Brunswick.*

The relation of the Paradoxides beds to those beneath will be better understood by a comparison of the Acadian measures at several localities with the typical Cambrian series of Sweden. So nearly alike were the physical conditions, during this early period of Cambrian time, in those two countries, that the symbols originally used in New Brunswick, to designate the groups of beds, have served to distinguish nearly similar sub-divisions in Sweden and Norway.

In these sections the base of the Paradoxides beds has been taken as the datum-line, and the thickness of the beds above and below this horizon, indicated on a scale of 100 feet to an inch.

In Sweden, the beds which belong to the lower part of the column, and are marked *b.*, are the "Olenellus beds" of that country: those marked *a.* are the Fucoid and Eophyton Sandstones which, by the discovery of F. Schmidt, in Eastern Russia, are also to be counted as a part of the Olenellus beds, since, as already observed, the corresponding beds in Russia contain a Mesonacis. The brachiopod (*Lingula*(?) or) *Mickwitzia monilifera*, which is found with this trilobite, and is common to the Cambrian of Russia and Sweden, occurs in the latter country at the base of the Eophyton sandstone, and this sandstone appears to correspond in position to the white weathering sandstone, *a*, at the base of St. John Group in New Brunswick.


SWEDEN.
NEW BRUNSWICK.
ST. JOHN CO.
KING'S CO.
ST. JOHN CO.
Andrarum & Lugnas.
Port-land.
Rad-cliff's.
Caton's Island.
Hanford's Brook, St. Martin's.
STAGE 2.
STAGE 1.
b-e
a-b
d^2
d^1
c
b
a^2
a^1
no fossils known.
Agnostus fissus.
Paradox. Abenacus cf. P. Tessini.
Paradox. Eteminic. cf. P. rugulosus.
Paradox. lamellatus cf. P Oelandicus.
Acrothele, &c.
Beyrichona, 2 sp.
Agraulos Diplotheca.
Ellipsocephalus Hipponicharion Leperditia, 3 sp. Acrothele, Acrotreta.
no fossils known.
Obolus pulcher
Fault
BASE OF THE ST. JOHN GROUP.
SECTIONS of LOWER CAMBRIAN STRATA in SWEDEN and NEW BRUNSWICK.
Scale 100 Feet to an Inch.

Of the sections of Cambrian Rocks in Acadia exhibited on the Table I, page 308, three are from theSt. John Basin, and the fourth from the northern basin in Kings Co., and they show clearly the varying thickness of the deposits of Division or Stage 1. in the different districts; this feature is much more noticeable in the lower bands (*a* and *b*) than in the upper *c* and *d*).

The most continuous and complete section found, is that on Hanford Brook, where the Cambrian measures are now separated from the rest of the St. John Basin by a low ridge of pre-Cambrian rocks; and from the differences that are observable in the details of the sections on the two sides of this ridge, it is probable that it existed in Cambrian times (compare the 3rd and 5th sections). Band *b* has its greatest thickness in the more distant basin in King's Co., (see fourth section), but does not show so much variety in the sedimentation as at the easterly exposures in the St. John Basin.

In this district at Hanford Brook, the fauna of 1 *b* presents itself in considerable variety. At the base, forty feet of the dark gray sandstone contains Ellipsocephalus and fragments of other trilobites; four entomostracans, viz., Hipponicharion and three species of Leperditia, which latter are remarkable for their thick tests, and pitted surfaces, and six species of brachiopods of the genera Acrothele, Acrotreta, Linnarssonia and Lingulella.

These sandstones are followed by fifty feet of comparatively barren, dark grey, sandy shales; and they by thirty feet of hard, purple-streaked sandstones, in which occurs an Agraulos of the form of *A.* (*Arionellus*) *primævus* of the bed *b* in Sweden, and the peculiar Hyalithoid shell *Diplotheca*, as well as numerous tracks of Psammichnites.

The olive grey shale, thirty feet thick, above this sandstone, is comparatively barren, but has yielded the two species of Beyrichona, a genus which has points of resemblance to Aristoze of Barrande.

The upper bed of *b*, twenty feet thick, is that already described as being cut up by worm burrows. In it the

brachiopodous genera *Acrothele*, *Lingulella* and *Linnarssonia*, are not uncommon, and the species are the same as found in the Paradoxides beds above.

There is thus, in Band *b*, an entomostracan fauna of six species, as well as two trilobites which resemble those of the Olenellus beds in Sweden, but so far, no example of Olenellus itself or its kindred genera. Band *b* has a thickness of 170 feet, and Band *a* of 200 feet, so we may suppose these measures at the base of the St. John Group, are very near the horizon of Olenellus.

If we were to be guided by the indications given by the Scandinavian faunas, we would place the Olenellus beds as a stage only, below the Paradoxides beds, and would not consider them worthy to rank as a series: but if we regard the great development of the measures containing Olenellus on the Pacific slope of the continent, we cannot refuse to accord to them the latter grade. It is a series which appears to overlap that containing Paradoxides, but which in its commencement assuredly had a higher antiquity.

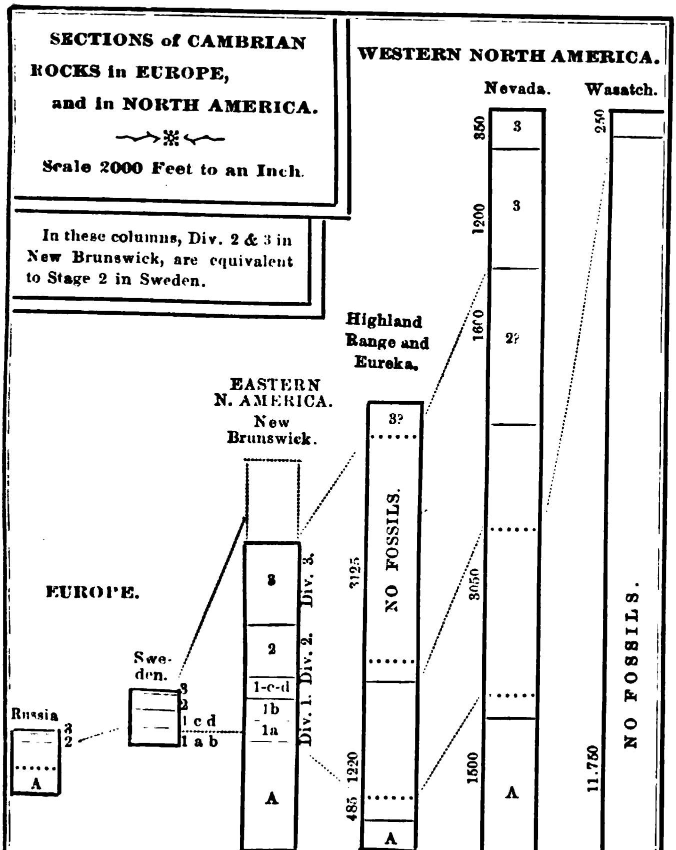
The author would, therefore, now arrange the Cambrian System, as it occurs in Acadia, as follows:—

	Localities.
D.—Upper Cambrian System (Potsdam series)...	Unknown.
C.—Middle and Lower Cambrian } Acadian Series,........	St. John, &c.
B.—Lower Cambrian, Georgian Series,..........	C. Breton.
A.—Basal Cambrian, Etcheminian Series,.......	St. John, &c.

The relation of the two latter series has not been clearly shown, but the observations thus far made in New Brunswick, and Newfoundland, agree with the scheme above presented.

3. *On the relations of the Olenellus faunas of the Pacific Slope in North America.*

The Olenellus fauna which we have been considering is not the full development of this fauna as known in the West.



CAMBRIAN IN RUSSIA.

3	Glauconite Sand	10 feet.		
2	Dictyonema Beds	10 "	=Divisions 2 and 3 in N.B.	
	Ungulite Grit	60 "		
A	Blue Clay	300 "	=Series A. in N.B.	A
	Iron Sandstone	300 "		
		680		

CAMBRIAN IN SWEDEN.

3	Ceratopyge Beds	12 feet.	
2	Peltura Beds	34 "	=Div. 3 in N.B.
	Olenus Beds	40 "	=Div. 2 in N.B.
1	Paradoxides Beds	90 "	=Div. 1 in N.B.
	Fucoid Sandstone	60 "	
	Eophyton Sandstone	20 "	
		256	

In that region there are two phases of the Olenellus fauna found at different levels in the measures of the Cambrian System, which may be distinguished as the Olenellus-Dorypyge phase, and the Olenellus-Bathyuriscus (*cf.* Ogygia) phase: it is the former only which is known in Eastern North America.

According to Mr. Walcott's sections, of which an outline is given on Table II, page 311, these two phases are separated by about 1,200 feet of measures, and the older is found some 1,500 feet or more above the base of the Cambrian system.

I have attempted to trace, by dotted lines, the respective horizons marked by these two phases of the Olenellus fauna, and for comparison, the position also of the Upper Cambrian fauna in the same region.

The basal measures of the Cambrian System, which in these sections are indicated by the letter A, are found in Norway, Russia, Newfoundland, New Brunswick and Western America, and probably also in Wales. As for the Cambrian measures which are above these, when they can be indicated with sufficient certainty, the Lower Cambrian is marked by 1, the Middle Cambrian by 2, and the Upper Cambrian, by 3, to show the range of the faunas in the several sections.

Mr. Walcott takes the Nevada section as the typical one for the West. In this the Upper Olenellus fauna extends 3,050 feet above the lower; and beyond this, for 1,600 feet, its forms are mingled with those of the Upper Cambrian or Potsdam fauna,[1] which, from its position, may be considered equivalent to the Ceratopye beds of Sweden. If there is this mingling of the species of the Olenellus beds with those of the Upper Cambrian, no place remains in Western America for the great North Atlantic faunas of the Paradoxides beds, and of the Lower and Upper Olenus beds. The only inference we can draw from this is, that the Upper Olenellus fauna and the Passage beds above were cotemporary with the three North Atlantic faunas above named.

[1] See Bull. U. S. Geol. Survey, No. 30, p. 32.

It has been stated in the notice of the meetings of the Geological Congress in London (1888) that Mr. Walcott's fauna of Olenellus, of forty-two genera, and 113 species,[1] is of earlier date than the Paradoxides bed, but from Mr. Walcott's own observations in the West, it is evident that this fauna should be divided, as only the Olenellus-Dorypyge phase can with certainty be placed below the Paradoxides zone.

In order to show the characteristic species of the Olenellus Bathyuriscus or later fauna of Olenellus, the writer has selected the following species, which, according to Mr. Walcott, belong to this horizon.

The genera marked with an asterisk, are found in the Paradoxides beds.

**Protospongia fenestra.*	*O. spinosus.*
**Eocystites* (??) *longidactylus.*	*O. typicalis.*
**Lingulella Ella.*	**Ptychoparia Housensis.*
**Kutorgina pannula.*	**P. Kingi,* (*Anomocare.*)
**Acrotreta gemma.*	**P. prospectensis* (")
**Acrothele subsidua.*	**P. quadrans* (")
**Orthis Highlandensis.*	*Crepicephalus Augusta.*
**Stenotheca elongata.*	*C. Liliana.*
**Hyolithes Billingsi.*	*Protypus senectus,* (cf. Ellipsocephalus.)
**Leperditia Argenta.*	*Bathyriscus Howelli,* (cf. Ogygia.)
**Agnostus intercinctus.*	*B. producta,* (").
Olenellus Gilberti.	*Asaphiscus Wheeleri,* (cf. Niobe.)
Olenoides lævis.	
O. Nevadensis.	

Among these species, *Acrotreta gemma* and *Acrothele subsidua* are similar to species of the Paradoxides beds. *Agnostus intercinctus* is a good example of the group of the Longifrontes, which has many species in the Upper Paradoxides beds, and some in the Lower. *Protospongia fenestrata* is a species of the Lower Paradoxides beds. Of the four species of Ptychoparia, three would by Swedish geologists be included in the same genus with *Anomocare micropthalmum*, also of the Paradoxides beds, and there are other

[1] See Bull. U. S. Geol. Survey, No. 30, p. 45.

Ptychopariæ which I do not make out clearly, from Mr. Walcott's notes, as of this horizon, but which probably belong here (*P. Piochensis*, and *P. coronata*) and these have a still closer resemblance to Anomocare. Olenellus and Olenoides may be considered as the representives of the Paradoxides family at this horizon, but the two last genera on the list find their representatives in Europe at a higher horizon than the Paradoxides zone, even as high as the summit of the Cambrian.

This remarkable grouping of genera, which it is stated gradually gave place to the Upper Cambrian fauna, would lead one to suppose that the introduction and removal of successive groups of marine forms in the West, during the Cambrian age, was governed by other conditions than those which prevailed in the better known regions around the North Atlantic Ocean.

In his former paper on the classification of the Acadian Cambrian Rocks, the writer considered the Olenellus fauna as a whole, but when the later phase of this fauna is removed, the evidence for the rest, *i.e.*, the Olenellus-Dorypyge phase, is in favour of its greater antiquity than the Paradoxides beds.

The great range of Olenellus in the west, as shown by Mr. Walcott's work, is unusual for a trilobite, but is parallelled by that of *Calymene Blumenbachii* in the Ordovician and Silurian and by other trilobites.[1] It is quite compatible with this feature, that the Olenellus-Dorypyge or older phase of the Olenellus fauna should also have a wide geographical range: accordingly, we find it spread all across the American continent, and although we do not know of the occurrence of Olenellus in Asia, its companion, Dorypyge, has been found in Northern China. Dr. F. Schmidt has described from a limestone on the Jenisei river, in Siberia, a trilobite which, by its form, agrees with the genus Dorypyge. Other Cambrian fossils are described in the same paper.

[1] *Protypus senectus* is also credited with a wide vertical range, but the examples figured are so defective that more than one genus may be included under the name.

In Europe, Olenelloid trilobites are again met with, but here, apparently, Dorypyge has not been found.

Taking this older phase of the Olenellus fauna as a basis, the two parellel series of trilobites may be represented in the following diagram:—

	North Pacific Basin.	North Atlantic Basin.	
3.	Upper Cambrian-Dikellocephalus-	Ctenopyge fauna,	3.
2	Middle Cambrian. / Passage beds to Upper Cambrian.	Peltura fauna........... / Olenus fauna............	2
1	OlenelleusBathyuriscus fauna. / Lower Cambrian.......	Paradoxides fauna...... / Olenellus–Dorypyge fauna......	1

This diagram is to be taken only as a suggestion of the possible relations of the Cambrian faunas on the two sides of the American continent, and is based upon our present knowledge. Paradoxides has been reported from Minnesota and from the Rocky Mountains on the line of the Canadian Pacific Railway; but imperfect examples of Olenellus and its allied genera so nearly resemble Paradoxides, that they are easily mistaken for it. They are distinguishable from Paradoxides by a decidedly reticulate ornamentation of raised lines on the surface of the crust, for in Paradoxides the lines are more or less parallel to each other.

Notes on the Flora of Montebello, Quebec, Estate of the Hon. Mr. Papineau.

By Henry R. Ami, M.A., Cor. Mem. Torrey Botan. Club.

At the Annual Field-day, held under the auspices of the Natural History Society of Montreal, on the 16th day of June, 1888, at Montebello, the various members of that Society had an excellent opportunity offered them, of examining the more salient characteristics of the natural phenomena existing in that locality. In and around the spacious grounds and estates of the Hon. Mr. L. J. Papineau,

kindly thrown open to the excursionists on that occasion, as also on a previous one (1881), the diversity of the soil and region, afforded quite a diversity of flora, as well as of fauna.

For example, *Cypripedium parviflorun*, *Habenaria dilatata?* *Arisæma triphyllum*, *Gaultheria procumbens*, *Linnæa borealis*, *Thuja occidentalis*, *Impatiens fulva*, *Oxcalis Acetosella*, *Goodyera pubescens*, *Pyrola elliptica*, *Thalictrum Cornuti* and other plants were noticed in the low-lying grounds, between the "manor" and the Canadian Pacific Railway track, whilst such species as *Comandra umbellata*, *Saxifraga Virginiensis*, *Prunus Pennsylvanica*, *Vaccinium vacillans*, *Asclepias Cornuti*, *Quercus rubra*, *Adiantum pedatum*, *Aquilegia Canadensis* and *Rubus odoratus* occupied the higher and dryer levels along the hill slopes and tops. It was a delight to meet with *Cypripedium acaule* in such numbers as were noted along the bluff of micaceous gneiss, close to the R. R. track, associated with *Chimaphila umbellata*, *Rubus villosus*, *Prunus Pennsylvanica*. The beautiful little "blue-eyed grass"—*Sisyrhynchium mucronatum*, noted for the rapidity with which it ripens or produces its fruit—was also observed in large numbers; this species is found skirting the edge of the Laurentides from north of Montreal westward to Ottawa and farther west. Besides the above, *Polygala paucifolia*, *Lathyrus ochroleucus*, *Geum rivale*, *Dirca palustris*, *Lycopus Virginicus*, *Cypripedium parviflorum*, *Symphoricarpus racemosus*, *var. pauciflorus* are amongst those species which are of usual occurrence, and of general interest along the Ottawa valley.

A few plants have escaped cultivation and are spreading, viz.:—*Arabis hesperidoides*, *Allium Schœnoprasum* and *Convallaria majalis*.[1]

In order to ascertain in general, what the flora of the grounds surrounding the "manor" was—a list of the species was made on the spot, subsequently systematized, and hereto appended :—

[1] *Vide* Trans. Ottawa Field Naturalists' Club, No. 3, 1882, p. 23.

List of species found growing within the grounds of Mr. L. J. Papineau, and in the village of Montebello adjoining.

P. represents the Papineau Estates; M. Montebello, for locality.

Clematis Virginiana, L. P.
Anemone dichotoma, L. P.M.
Anemone Hepatica, L. P.
Thalictrum Cornuti, L. P.
Ranunculus abortivus, L. P.
" *acris, L.* P.M.
" *recurvatus, Poir.* P.
Coptis trifolia, Salisb. P.
Aquilegia Canadensis, L. P.
Actæa alba, Bigelow, P.
" *spicata, L. var. rubra, Ait.* P.
Chelidonium majus, L. P.
Cardamine pratensis, L. P.
Arabis hesperidoides, Gray. P.
Brassica alba, Gray. M.
" *Sinapistrum, Boiss.* M.
Capsella bursa-pastoris, Mœnch. M.P.
Thlaspi arvense, L. M.
Viola cucullata, Ait. P.
Cerastium vulgatum, L. M.P.
Tilia Americana, L. P.
Geranium Robertianum, L. P.
Impatiens fulva, Nutt. P.
Oxalis Acetosella, L. P.
" *corniculata, L. var stricta,* L. P.
Rhus Toxicodendron, L. P.
Rhus typhina, L. P.
Ampelopsis quinquefolia, Michx. P.
Acer Pennsylvanicum, L. P.
" *rubrum, L.* P.
" *saccharinum, L.* P.
" *spicatum, Lam.* P.
Polygala paucifolia, Willd. P.
Trifolium repens, L. P.M.
" *pratense, L.* P.M.
Medicago Lupulina, L. P.M.
Lathyrus ochroleucus, Hook. P.
Robinia viscosa, Vent. P.
Prunus Pennsylvanica, L. P.
" *Virginiana, L.* P.
Geum rivale, L. P.
Fragaria vesca, L. P.
" *Virginiana, Ehrh,* P.M.
Rubus odoratus, L. P.
" *strigosus, Michx.* P.M.
" *triflorus, Tich.* P.
" *villosus, Ait.* P.
Pyrus Americana, D.C. P.
Amelanchier Canadensis, v. oblongifolia, T. & G. P.
Ribes Cynosbati, L. P.
" *lacustris, Poir.* P.
*Saxifraga Virginiensis, Michx.*P.
Mitella diphylla, L. P.
" *nuda, L.* P.
Tiarella cordifolia, L. P.
Epilobium spicatum, L. P.
Sanicula Marilandica, L. P.
Osmorrhiza brevistylis, D.C. P.
Aralia nudicaulis, L. P.
Cornus Canadensis, L. P.
" *circinata, L'Her.* P.
" *stolonifera, Michx.* P.M.
Linnæa borealis, Gronov. P.
Symphoricarpus racemosus, Mix, var., pauciflorus, Robbins, M.
Lonicera ciliata, Muhl. P.
Diervilla trifida, Mœnch. P.
Sambucus Canadensis, L. P.
Viburnum acerifolium, L. P.
" *Opulus, L.* P.
Galium asprellum, Michx. P.
" *triflorum, L.* P.
Aster cordifolius, L. P.
Aster macrophyllus, L. P.
Erigeron Philadelphicum, L. P.
" *strigosum, L.* P.
Bidens frondosa, L. P.
Anthemis Cotula, L. M.
Achillæa millefolium, L. P.M.
Chrysanthemum Lecanthemum, L. M.
Artemisia vulgaris, L. M.
Antennaria plantaginifolia, R. Br. P
Cnicus arvensis, Scop. M.P.
Lappa officinalis, All. M.
Cichorium Intybus, L. M.
Nabalus sp. P.
Taraxacum officinale, Weber, M.P.
Vaccinium Pennsylvanicum, L. P.
Vaccinium vacillans Solander. P.
Gaultheria procumbens, L. P.
Pyrola elliptica, Nutt. P.
" *secunda, L.* P.
Chimaphila umbellata, Nutt. P.
Plantago major, L. P.M.

Plantago Rugellii, Decaisne. P.
Trientalis Americana, Pursh. P.
Veronica serpyllifolia, L. P.M.
Lycopus Virginicus, L. M.
Leonurus Cardiaca, L. M.
Cynoglossum, officinale, L. M.
" *Virginicum, L.* P.
Apocynum androsæmifolium, L. P.
Asclepias Cornuti, Decaisne. P.
Fraxinus pubescens, Lam. P.M.
Chenopodium album, L. P.M.
Atriplex patula, L. P.M.
Polygonum aviculare, L. M.
" *cilinode. Michx.* P.
" *hydropiper, L.* P. & M.
Rumex Acetosella, L. P.M.
" *verticillatus, L.* P.M.
Dirca palustris, L. P.M.
Comandra umbellata, Nutt
Ulmus Americana, L. P.M.
" *fulva, Michx.* M.
Juglans cinerea, L. P.
Quercus alba, L. M.
" *rubra, L.* P.
Fagus ferruginea, Ait. P.
Corylus rostrata. Ait. P.
Carpinus Americana, Michx. P.
Betula papyracea, Ait. P.
" *lena, L.* P.
Alnus incana, Willd. P.
Salix (several species). P. & M.
Populus balsamifera, L. P.
" *grandidentata, Michx.* P.
" *tremuloides, Michx.* P.
Pinus Strobus, L. P.M.
" *resinosa, Ait.* P.
Picea alba, Link. P.
Abies balsamea, L. P.
Pseudotsuga Canadensis, Michx: P.
Larix Americana, Michx. P.
Thuja occidentalis, L. P.
Juniperus communis, L.
Arisæma triphyllum, Torrey P.
Typha latifolia, L. P.
Alisma plantago, L. var. Americana, Gray. P.
Habenaria dilatata, Gray. P.
Goodyera pubescens, R. Br. P.
Cypripedium acaule, Ait. P.
" *parviflorum, Salisb.* P. (1881.)
Iris versicolor, L. P.
Sisyrhynchium mucronatum, Michx. L. P.M.
Smilax herbacea, L. P.M.
Trillium grandiflorum, Salisb. P.
Medeola Virginica, L. P.
Streptopus roseus, Michx. P.
Uvularia sessilifolia, L. P.
Clintonia borealis, Raf. P.
Smilacina racemosa, L. Desf. P.
Mianthemum Canadense, Desf. P.M.
Erythronium Americanum, Smith. P.
Allium Schœnoprasum, L. P.
Convallaria majalis, L. P.
Scirpus atrovirens, Muhl. P.
Carex intumescens, Rudge.
" *laxiflora, Lam.* P.
" *riparia, Curtis.* P.
" *stellulata, L.* P.
Agrostis vulgaris, With.
Calamagrostis Canadensis, Beauv. P.
Phleum pratense, L. P.M.
Equisetum hyemale, L. M.
" *sylvaticum, L.* P.
Pteris aquilina, L. P.M.
Adiantum pedatum, L. P.
Phegopteris Dryopteris, Fee. P.
Aspidium Thelypteris, Swz. P.
Onoclea sensibilis, L. P.
" *Struthiopteris, Hoffm.*
Botrychium Virginicum, Swz. P.
Lycopodium clavatum, L. P.
" *complanatum, L.* P.

OTTAWA, *June 20th,* 1888.

METEOROLOGICAL ABST

Observations made at McGill College Observatory, Montreal, Canada. — Hei

Month.	Thermometer. Mean.	¶ Deviation from 14 year means.	Max.	Min.	Mean daily range.	* Barometer. Mean.	Max.	Min.	Mean daily range.	Mean pressure of vapour. †	Mean relative humidity. ‡	Mean dew
January	3.66	− 7.24	40.0	− 20.5	15.09	30.1413	30.865	29.538	.333	.0446	78.8	—1
February	12.42	− 3.15	38.6	− 24.4	20.28	30.0971	30.617	29.514	.314	.0737	79.6	7
March	23.22	− 0.11	44.2	− 2.9	13.21	29.9866	30.563	29.173	.250	.1077	76.8	16
April	36.85	− 2.46	76.0	11.4	13.66	30.0719	30.507	29.544	.217	.1493	67.0	26
May	53.55	− 1.07	79.8	31.1	16.65	29.9576	30.306	29.555	.145	.2631	63.4	40
June	65.81	+ 1.24	88.1	46.5	18.16	29.8603	30.238	29.479	.161	.4319	67.0	53
July	67.93	− 1.17	87.1	47.4	20.04	29.9051	30.232	29.186	.161	.4190	62.2	53
August	64.18	− .07	85.8	47.6	14.28	29.8849	30.285	29.624	.138	.4562	75.5	55
September	55.43	− 3.03	74.0	33.2	13.56	30.0342	30.621	29.485	.147	.3556	78.9	48
October	39.51	− 5.84	58.0	28.5	11.31	29.9184	30.478	29.386	.215	.1913	77.9	32
November	33.25	+ 1.33	68.0	1.0	12.09	30.0876	30.804	29.354	.291	.1761	80.5	27
December	22.39	+ 3.70	45.8	− 10.5	13.18	29.9220	30.558	29.283	.266	.1128	80.8	17
Sums for 1888	...	...	....	....	....		....	....	....	....		..
Means for 1888	39.83	− 1.74	....	....	15.12	29.9889	....	....	.223	.2318	74.0	31
Means for 14 years ending Dec. 31, 1888.	41.58	....	...	....	...	29.9760	....	....	....	.2489	74.3	..

* Barometer readings reduced to 32° Fah., and to sea level. † Inches of mercury. ‡ Saturation, 100. § F
for 14 years, inclusive of 1888. The monthly means are derived from readings taken every 4th hour, beginning
above the ground, and 810 feet above sea level.

The greatest heat was 88.1 on June 22nd; greatest cold 24.4 below zero on February 10th; extreme range
range was 2.3 on Nov. 28th. The warmest day was June 22nd, when the mean temperature was 77.52. The col
on January 16th, the lowest was 29.173 on March 21st, giving a range of 1.692 for the year. The lowest relativ
the greatest velocity in gusts was at the rate of 90 m. p. h. for 3 miles, and 110 m. p. h. for 1 mile, on March 13
resultant mileage 60,750. Auroras were observed on 21 nights. Fogs on 31 days. Hoar-frost on 15 days. Thu
nights. The sleighing of the winter closed, in the city, on April 7th. The first appreciable snowfall of the au

The mean temperatures for January and December are the lowest on the records for the 14 years over wh
was an earthquake rumble on July 1st.

...ACT FOR THE YEAR 1888.

...bove sea level 187 ft. Latitude N. 45° 30′ 17″. Longitude $4^h\ 54^m\ 18^s.55$ W.

C. H. McLEOD, *Superintendent.*

Wind. Resultant direction.	Wind. Mean velocity in miles per hour.	Sky clouded per cent.	Per cent. possible bright sunshine	Inches of rain.	Number of days on which rain fell.	Inches of snow.	Number of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain and snow fell.	No. of days on which rain or snow fell.	Month.
.77° W.	18.68	50.4	41.2	0.08	2	33.6	17	2.81	2	17	January ....
.44° W.	17.19	54 2	45.3	0.55	2	30.0	16	2.71	2	16	February........
.64° W.	22 26	79.6	31.4	1.17	6	25.2	14	3.45	3	17	March ....
.81° W.	16.28	60.6	54.1	0.80	11	7.1	12	1.54	6	17	April. ....
.46° W.	13.24	67 8	45.0	1.97	16	Inapp.	1	1.97	1	16	May ....
.89° W.	13.47	59 6	58.9	3.12	19	..	..	3.12	..	19	June............
.73° W.	13.31	52.1	69.2	1.32	13	..	..	1.32	..	13	July............
.70° W.	12.54	65.4	43.4	7.89	19	.	..	7.89	.	19	August..........
.65° W.	11.46	60.8	48.2	3.69	16	..	..	3.69	.	16	September.......
W.	15.85	69.8	36.3	3.82	22	7.8	5	4.55	2	25	October.........
.65° W.	17.65	74.0	33.2	5.10	16	11.0	10	6.40	4	22	November.......
.81° W.	18.53	74.4	25.1	1.57	8	17.6	17	3.12	2	23	December........
	....	....	....	31.08	150	132.3	92	42.57	22	220	Sums for 1888 ...
74° W.	15.85	64.1	44.3	....	....		....	3.55	..	18.3	Means for 1888...
....	...	61.2	§46.4	27.20	132	125.8	85	39.66	15	202	Means for 14 years ending Dec. 31, 1888.

...only. ¶ "+" indicates that the temperature has been *higher;* "—" that it has been *lower* than the average
...6m, Eastern Standard time. The anemometer and wind vane are on the summit of Mount Royal, 57 feet

...perature was therefore 112.5. Greatest range of the thermometer in one day was 50.1 on Jan. 18th; least
...was Feb. 10th, when the mean temperature was 15.90 below zero. The highest barometer reading was 30.865
...ity was 23 on May 26th. The greatest mileage of wind recorded in one hour was 62 on November 26th, and
...total mileage of wind was 139,808. The resultant direction of the wind for the year is S. 74° W., and the
...orms on 20 days, and lightning without thunder on 8 days. Lunar halos on 9 nights. Lunar coronas on 7
...on October 3rd. The first sleighing of the winter was on December 18th.

...present series of observations extends. The rainfall for August is the greatest recorded in 14 years, There

NOTICES.

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AND REPLACING

THE CANADIAN NATURALIST.

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1889.

THE

CANADIAN RECORD

OF SCIENCE.

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Glaciation of Eastern Canada.

By Robert Chalmers,

Of the Geological Survey of Canada.

The investigations hitherto made in regard to the glaciation of Eastern Canada show that, instead of its having been caused by a continental ice-sheet moving over the region from north to south, as has been supposed, local glaciers upon the higher grounds, and icebergs or floating ice striating the lower coastal and estuarine tracts, during a period of submergence, were agents sufficiently powerful to produce all the phenomena observed. The latter theory, with some modifications, is the one so long maintained by Sir William Dawson, who has studied the glaciation of this country for forty years or more.[1] A number of other observers have, of late years, been at work, however, and Sir William's views are now, it would seem, about to receive abundant confirmation. The large

[1] Acadian Geology, 2nd and 3rd eds., Chap. on Post-Pliocene; Notes on the Post-Pliocene Geology of Canada, *Canadian Naturalist*, 1872; Geological Magazine, March, 1883, and numerous addresses and papers in *Canadian Naturalist, &c.*

mass of new evidence obtained, and now available for co-ordination and study is, however, so scattered through the reports of the Geological Survey and various scientific periodicals, as to be somewhat difficult of access. A good deal of unpublished material, too, relating to this subject, is now in the hands of the Geological Survey staff. My object in this paper therefore is simply to collect and correlate all the main facts within reach relating to this important question, briefly summarizing the results, and referring the student for fuller details to the reports and publications alluded to.

Commencing in the extreme eastern part of Canada I shall give a brief statement of the facts observed in each province, correlating those pertaining to each of the larger centres of dispersion for local glaciers, such as the Cobequid Mountains in Nova Scotia, the main central water-shed in New Brunswick, the Notre Dame or Shickshock Mountains in the province of Quebec, etc. Each of these centres formed a gathering ground for its own glaciers, discharging them on either side, or in various directions according to the slopes of the land.

It is, perhaps, necessary at the outset to define the term "local glacier," as I understand it. By a local glacier I mean an ice-sheet limited in extent, that is, confined to one valley or hydrographic basin, whether large or small, and influenced in its movement by local topographic features, such as mountains, water-sheds, hills, or river valleys.

NOVA SCOTIA.

In Nova Scotia it is found that ice moved in different directions in different localities, the slopes of the country having largely controlled it. The Cobequid Mountains shed ice from their summits on either side, that is, northward and southward; and the South Mountain likewise discharged glaciers off its slopes. Observations on the glaciation of that province by Sir William Dawson show a wide divergence in the courses of striæ met with in a number of different places. This seems explicable only on

the theory of local glaciers and icebergs as held by him.[1] Dr. Honeyman gives several lists of striæ also, from various parts of the province, and discusses the phenomena pertaining thereto, adhering however, to the view of a continental glaciation. He notes however the northward transportation of boulders from the South Mountain at Nictaux, Berwick, etc.[2] Mr. Chas. Robb,[3] and Mr. Hugh Fletcher, especially the latter gentleman, have made numerous observations on striæ, etc., in Cape Breton and in the eastern and north-eastern part of the peninsula. Mr. Fletcher's lists are given independent of any theoretical views, which makes them, perhaps, all the more valuable. They show that ice moved down the slopes from the higher grounds everywhere, usually following river valleys.[4] Dr. R. W. Ells investigated the glacial phenomena of Cumberland county to some extent.[5] Between River Herbert and South Joggins he found striæ in the direction of S 63° W, the ice producing these having apparently come from the higher grounds north-east of Maccan and flowed towards Chiegnecto Bay. In the pass in the Cobequids, through which the Spring Hill and Parrsboro' Railway runs, striæ indicating the passage of ice through it and flowing towards Minas Basin were observed. On the south slope of these mountains, at New Mines, an escarpment of rock has its face striated by ice which flowed towards the outlet of Minas Basin. At New Annan, on the north side, grooves and striæ were seen with a course of N. 10° E., showing that ice flowed northward from their summits down the French River valley towards Tatamagouche Bay. Mr. E. R. Faribault of the Geological Survey, who has been studying the gold regions in eastern Nova Scotia, also

[1] Acadian Geology, 2nd ed., p. 62.

[2] Nova Scotia Institute of Natural Science, Proceedings of, Vols. IV., V., VI. and VII.

[3] Report of Progress, Geol. Surv. of Canada, 1874-75.

[4] Reports of Progress, Geol. Surv. of Canada, from 1875-76 to 1882-83-84, also Annual Report, 1886, Vol. II., p. 104 P.

[5] Annual Report, Geol. Surv. of Can., 1885, Vol. I, 63-64 E.

informs me that he finds the striæ, generally, running down hill towards the coast.

From all the data before us, therefore, it would appear that ice which accumulated on the surface of the province moved from the higher grounds down the slopes in the nearest direction to the sea. This certainly is not the action of other than local glaciers. Some of the coastal tracts have, no doubt, been glaciated by icebergs or floating ice, however, similarly to the sea and estuarine borders in New Brunswick and Quebec, as shown by Sir William Dawson.[1]

New Brunswick.

The glacial phenomena of New Brunswick have been studied, perhaps, in greater detail than those of any other part of Eastern Canada. A number of observers have, from time to time, published lists of striæ, among whom may be mentioned the late Prof. James Robb,[2] G. F. Matthew,[3] Prof. H. Y. Hind,[4] Dr. R. W. Ells,[5] and the writer,[6] The greater number of striæ recorded in the publications referred to, however, occur on the southern slope of the main central water-shed traversing the province from north-west to south-east, and were supposed to lend support to the theory of a continental, or very large ice-sheet, passing over the country south-eastwardly, that being the average trend of the striæ in that part of New Brunswick. My own investigations, continued for more than fifteen years, and extending to all parts of the province, have, however, led me to a different conclusion. North of the

[1] Notes on the Post-Pliocene Geology of Canada, *Canadian Naturalist*, 1872.

[2] Proceedings of the Am. Ass. for Advancement of Science, 1850.

[3] Report of Progress, Geol. Surv. of Can., 1877-78, part EE.

[4] Preliminary Report on the Geology of New Brunswick, 1864.

[5] See list of Striæ, Annual Report, Geol, Surv. of Canada, 1885, Vol. I, part GG.

[6] Report of Progress, Geol. Surv. of Canada, 1882-84, part GG; Annual Report, 1885, Vol. I, part GG; Annual Report, 1886, Vol. II., part M; *Canadian Naturalist*, Vol. X, Nos. 1 and 4.

principal water-shed referred to, it was found the striæ had an entirely different course from those south of it, indicating ice-movement eastwardly and north-eastwardly towards the Gulf of St Lawrence. This was especially noticeable in the Baie des Chaleurs and Miramichi basins, on the south and south-western sides of which striæ occur trending towards all points of the compass between north and east. Hence I inferred that the chief water-shed of the province referred to shed the ice in both directions as indicated by the striæ.[1] The striæ follow the river valleys, however, to a large extent, the ice producing them having been influenced more or less also by the minor topographic features of the slopes.

Considerable areas in the interior and also upon the Carboniferous plain are found to be unglaciated. In the former, no ice action whatever was apparent, the rocks standing up with jagged, broken surfaces, and covered with their own debris, while nothing like boulder-clay can be seen. On the coastal area of the Carboniferous plain I observed boulder-clay and transported blocks overlying decomposed rock *in situ*.

From these facts I conclude that the ice-covering of the province during the glacial period consisted of local glaciers only, the central area being mainly a gathering ground for the snow and ice, which sent off glaciers in opposite directions. Some of these glaciers, however, must have been quite large. The western end of the Baie des Chaleurs basin appears to have been occupied with one which drew its supplies from the west, north and east, *i. e.* from the Restigouche, Nouvelle and Cascapedia valleys, etc.[2] But the largest local glaciers were, undoubtedly, those which occupied the southern slope of the New Brunswick water-shed. They probably filled the St. John valley and spread over the minor water-shed, between it and the Bay of Fundy. Impinging against the coast hills of St. John

[1] Annual Report Geol. Surv. of Canada, Vol. I, part GG.

[2] Annual Report, Geol. Surv. of Canada, 1886, Vol. II, part M; *Canadian Naturalist*, Vol. X, Nos. 1 and 4.

and Charlotte counties they must have partly over-ridden some of these in their passage to the Bay of Fundy, and were, at least, two to four hundred feet in thickness. Striæ are found on the north-west flanks of these hills three to four hundred feet above the general level of the district to the north, over which the ice approached them. This district, now nearly level, or but slightly undulating, and extending from the interior of the province, or the central water-shed, to the coast hills mentioned, forms an inclined plane, along which the moving glaciers must have acquired great momentum. Passes exist in these coast hills, through which the glaciers sought outlet to the bay, but some portions of them must have been shoved up on the northern flanks of the elevations between these passes to a height nearly equal to its source on the upper slopes of the central water-shed. These facts and others, which cannot here be given in detail, go to show that the glaciers of this slope must have been quite large, at least in this particular area. The coast hills referred to broke them up, however, as the ice passed through these gaps, as is shown by the wide deviations in the courses of the striæ before their final disappearance on the shores of the Bay of Fundy.[1]

Numerous moraines exist in the western part of the province which could only be formed by local glaciers descending from the hilly tracts into the valleys, as, for example, into the basin of the Chiputnecticook Lakes, or the valley of the Magaguadavic River, etc.[2] Considerable deviations in the courses of striæ occur in the hilly district further east.[3] Near the lower St. John, and along the Kennebeckasis valley, as well as in the highland region between the latter and the Bay of Fundy, striæ are seen running in various directions. The glaciers here must have been small and apparently independent of each other. The

[1] These remarks are based on observations made by the Geol. Surv. staff, but not yet published.

[2] Report of Progress, Geol. Surv. of Can., 1882-84, part GG.

[3] From data obtained in the field by the writer during the seasons of 1887 and 1888, not yet published.

divergent courses of striæ, often seen upon the same rock surface, are, however, sometimes explicable on the theory of their having been produced by successive portions of the diminishing glaciers conforming, in their motions, more closely to the surface features during the period of melting. Along valleys, which were under the sea during the latter part of that period, as, for instance, those of the Petitcodiac and Kennebeckasis rivers, the striæ, which in some cases are parallel thereto, may have been produced by floating ice, and the same remark applies to striæ met with on the isthmus of Chiegnecto.[1] Certain fine ice markings, found also on the immediate coast of the Baie des Chaleurs, seem attributable to the same cause. It is probable that during the ice age the eastern part of this bay, at least, was open, and that floating ice grated the rocks along its shores.

Prince Edward Island.

Prince Edward Island has probably been glaciated similarly to the coastal areas of New Brunswick and Nova Scotia. Sir William Dawson gives the courses of striæ observed in two places; but it is an open question whether local glaciers of its own or icebergs produced them.[2] Other phenomena noted by Sir William rather point to the latter as the probable cause of these.

Quebec.

The glaciation of the Province of Quebec presents much greater complexities than are to be found in that of the Maritime Provinces of Canada. It would seem that the estuarine portion of the St. Lawrence River, at least, was partially open during the period of extreme cold, similarly to the Baie des Chaleurs, as just stated. The Notre Dame range of mountains, or the water-shed adjacent thereto, shed the ice northward and southward, part of which *debouched* into these waters. Observations made by Dr. R. W. Ells

[1] Annual Report, Geol. Surv. of Can., 1885, Vol. I, part GG.; list of striæ.

[2] Supplement to Acadian Geology, p. 25.

and the writer abundantly prove this.[1] In 1872 Sir William Dawson pointed out that "local glaciers had "*debouched* into the St. Lawrence valley from the north "following the valleys of the Saguenay and Murray Bay "rivers, etc., and *possibly also from the south*."[2] But it was not until the year 1885 that positive evidence of a northward ice movement on the southern slope of the St. Lawrence valley was found by the writer.[3] The following year Dr. Ells discovered similar evidence in the Eastern Townships confirming, beyond doubt, the above conclusion.[4] From a large number of facts adduced in the report referred to he infers that "local glaciers were shed on either side "from the great mountain ridge along the Maine and New "Hampshire boundary. On the sonth-east slope of the "boundary chain the striæ are found to be about S. 65° E., "while on the Quebec slope the general course is the "reverse, or N. 65° W. (true meridian.) About Lake "Megantic and further south, in Ditton and Emberton, "however, a general N.-W. course was observed. Along "the Chaudiere and Du Loup rivers, the striæ, in general, "trend N. 55° W."[5] During the two seasons since, Dr. Ells has obtained a large number of additional facts in this region, corroborating the foregoing conclusion and showing that local glaciers alone must have produced all the striation from the summit of the Notre Dame or Appalachian mountain range to the St. Lawrence valley

The grooves recorded in *Geology of Canada*, 1863, pages 890-92, as occurring in this region, have also, it appears, been produced by northward moving ice.[6]

[1]Annual Report, Geol. Surv. of Can. 1886, Vol. II, 44-51 J; ibid., 5-20 M; also Transactions Royal Soc. of Can., 1886, Sec. IV, Art. X.

[2]Notes on the Post-Pliocene Geology of Canada, 1872. *Canadian Naturalist*, Vol. IV, No. 1, p. 30.

[3]Transactions Royal Soc. of Canada, 1886, Sec. IV., Art. X. Geol. Surv. of Can. 1886, Vol. II, part M.

[4]Ibid., part J.

[5]Annual Report, Geol. Surv. of Can., 1886, Vol. II, 45 J.

[6]Transactions Royal Soc. of Can., 1886, Vol. IV, Art. X.

Further to the east, at Lake Temiscouata and vicinity, Prof. L. W. Bailey and Mr. W. McInnes, of the Geological Survey, found striæ and transported blocks, evidencing north-westerly ice movement from the summits of the water-shed.[1]

On the south-east slope of the mountain range mentioned, abundant evidence has been obtained in Canadian territory showing a general south-eastward ice-flow. Besides the striæ met with in the Temiscouata Lake valley,[2] I found others in the Madawaska River valley,[3] also on the Quatawamkedgewick, a branch of the Restigouche River.[4] Striæ have been seen also near the Matapedia Lake,[5] and further east, near the mouth of the Restigouche, as well as in numerous places along the north side of the Baie des Chaleurs,[6] all of which have a general south-easterly course. There were local deflections, however, caused by hills and river valleys, and especially by the slopes of the Baie des Chaleurs district.

In the St. Lawrence Valley, on ledges below the 350 to 375 contour line, striæ and polishing were observed, indicating ice movement in the general direction of the valley, that is, about north-east and south-west. These must have been caused by drift ice, as shown by Sir William Dawson.[7]

Co-ordinating all the phenomena relating to the glaciation of that portion of Quebec lying south of St. Lawrence River, we find that local glaciers upon the higher grounds and slopes and drift ice on the lower are sufficient to

[1]Science, Vol. VIII, p. 412.

[2]Geology of Canada, 1863, pages 890-92.

[3]Annual Report, Geol. Surv. of Can., 1885, Vol. 1, list of striæ, part GG.

[4]Annual Report, 1886, Vol. II, List of Striæ, part M.

[5]Geology of Canada, 1863, pages 890-92.

[6]Annual Report, Geol. Surv. of Can., 1886, Vol. II, list of striæ, part M.

[7]Acadian Geology, 3rd ed. Notes on the Post Pliocene Geology of Canada, 1872, *Canadian Naturalist*. Transactions Royal Soc. of Can., 1886, Sec. IV, Art. X. Annual Report Geol. Surv. of Can., 1886, Vol. II, part M.

account for them. These local glaciers drew their supplies from large gathering grounds on the water-shed along the Notre Dame or Green Mountain Range. Generally speaking, they were shed on either side of the Appalachians, nearly at right angles to their axis, which accounts for the parallelism or correspondence in direction of the striæ referred to by Dr. Ells.[1] The river valleys and minor ridges and hills on the slopes, however, caused many local deviations from the normal course. On the south-east slope, their movements were, perhaps, subjected to greater local deflections than in the north-west, caused by the rugged topographic features which are upon it. For example, the chief water-shed of New Brunswick, already referred to as lying between the St. John valley and the Baie des Chaleurs and Gulf of St. Lawrence, shed the ice of the southern slope of the Notre Dame mountains once more in nearly opposite directions, or north-eastward and south-eastward.[2] On these minor slopes, local surface inequalities again swerved the ice-masses, in a greater or less degree, from the courses given to them by the New Brunswick water-shed, etc. For the most part, they followed the nearest slopes or river valleys, thus showing their essentially local character. During the period of melting or retirement of the glaciers, this became more and more apparent.

The Laurentian or Archæan Area.

The glacial phenomena of the Archæan Area north of the St. Lawrence and great lakes, have also undergone investigation by the Geological Survey staff, and a large number of facts collected relating thereto, in addition to those recorded in *Geology of Canada*, 1863, and in Sir William Dawson's Notes on the Post-Pliocene, etc. Along the St. Lawrence valley, the general parallelism of the Laurentide slope to that of the Notre Dame Range opposite caused the striæ to have nearly a similar south-east and north-west

[1]Ibid, part J.

[2]Annual Report, 1885, Vol. I, part GG.

course,[1] the ice producing them having moved down the slope mentioned in the St. Lawence valley from the north. But south of the water-shed, separating the waters of the Ottawa River from those of the great lakes, the striæ are found to swerve more to the south and south-west. Immediately north of lakes Huron and Superior they have a south-westerly trend,[2] and this appears to be the normal course along the border of the Archæan Area to Lake of the Woods, and as far as Lake Winnipeg, in the latter region, perhaps, having a little more westing.[3] On the east side of Hudson Bay, striæ have been observed by Dr. R. Bell[4] and Mr. A. P. Low of the Geol. Survey (report of latter gentleman not yet published) to run westwardly into its basin mainly following the valleys. On islands in the northern part of Hudson Bay, Dr. Bell found striæ indicating a northward flow of ice;[5] while at Hudson Straits, the course appears to have been north-east and east.[6]

On the east and south-east coast of Labrador there is evidence, according to Packard, that the ice followed the valleys and nearest slopes to the sea.[7]

It would seem therefore, that there was an outward flow of ice radially around the margin of the great Archæan Area. Whether the whole area was occupied by glaciers moving from the centre towards the circumference, or the central portion was largely covered with masses of snow

[1] Geolgy of Canada, 1863, pp. 890–92, Notes on the Post-Pliocene, &c. *Can. Naturalist*, 1872.

[2] Geol. of Can., 1863, pp. 890–92. Dr. R. Bell, Report of Progress, Geol. Surv. Can. 1869; Report of Progress, 1873; Annual Report, 1886, Vol. II, part G.

[3] Dr. G. M. Dawson, Geology and Resources of the Forty-ninth Parallel; Dr. Bell, Report of Progress, 1877–78, part CC.; A. P. Low, Annual Report, 1886, Vol. II, part F. Dr. A. C. Lawson, Annual Report, Vol. I, part CC.

[4] Report of Progress, Geol. Surv. Can. 1877–78, part C.

[5] Annual Report Geol. Surv. Can., 1885, Vol. I, p. 14 DD.

[6] Report of Progress, Geol. Surv. Can. 1882–83–84, p. 36 DD.

[7] See paper by A. S. Packard, Jr., M.D. *Silliman's Journal*, and re-published in *Can. Naturalist*, Vol. II, 1865, p. 441.

and ice only, and formed a gathering ground which sent out local glaciers in all directions, as seems more probable, is a question to be decided by future investigations. The southern or southwestern portions are intensely glaciated, especially in the Lake Superior and Lake of the Woods regions.[1] There seems no doubt that the glaciers there were large and probably became confluent.

General Conclusions.

Summing up the data thus far obtained, I conclude that the glaciation of Eastern Canada has been effected by local glaciers on the higher grounds, and drift-ice or ice-bergs on the lower coastal areas. In their movements, the glaciers, generally speaking, followed the slopes of the land, or the drainage channels. They seem to have had extensive gathering grounds upon the more elevated parts of the country where snow-fields and *nevé*-ice existed. Whenever motion began, these became converted into glacier-ice. Upon those areas where the snow never underwent change into ice no striation of the rocks is found. Some of the glaciers appear to have been quite large, and those from adjacent drainage areas may have coalesced on the lower grounds and become confluent. At all events, the slopes and coastal tracts are, generally speaking, more glaciated than the interior and higher grounds. Each area or centre of dispersion has, however, had its own glacier or glaciers. In Nova Scotia there was a shedding of the ice from the Cobequid Mountains northward and southward; and probably the elevation known as the South Mountain likewise sent glaciers down its slopes on either side. In New Brunswick, the low water-shed running across it from north-west to south-east, sent off glaciers in opposite directions, or north-eastwardly on the northern slope and south-eastwardly on the southern, these courses being deviated from in a greater or less degree, however, according as the ice was influenced by local topographic features. The Shickshock or Notre

[1] Dr. G. M. Dawson, Geology and Resources of the Forty-ninth Parallel. Annual Report Geol. Surv. of Canada, 1885, Vol. I, part CC.

Dame Range, in Quebec, and its continuation south-westwardly along the International boundary, likewise shed the ice in both directions at about right angles to the main axis of the chain, that is, nearly south-eastward and north-westward; while the Archæan Area north of the St. Lawrence and great lakes sent sheets of ice down its slopes in all directions around its circumference. On the east side of Hudson Bay, the ice moved directly westward into its basin according to Dr. R. Bell and Mr. A. P. Low.

Considerable areas of rock surface in the interior and more elevated portions of Eastern Canada, where gathering grounds for glaciers may be supposed to have existed, are without striæ or other evidence of glaciation, the decomposed rock lying undisturbed, except from subærial action, and boulder-clay being absent. Occasional smaller patches of similar character are met with near the coast. These during the ice age were probably covered by snow only, or by ice which had little or no motion.

The extent and thickness of the glaciers cannot as yet be satisfactorily determined from the data at hand. But it is evident some of them were quite large, and the larger ones appear to have been on the southern slopes of the Appalachians and Laurentides. The cause of this is not apparent, but as regards those of the former mountain range, it may be due, in some measure, to the difference in the steepness of the slopes on either side of it. The south-eastern slope is long, much broken, and has numerous comparatively level areas upon it. As the rate of motion would be slower on this slope, the ice would necessarily accumulate in larger sheets in the depressions and on level tracts. On the shorter and more abrupt slope of the St. Lawrence the motion of the glaciers would be more rapid, they would more readily *debouch* in the estuary or sea, and hence there would be less chance for accumulation in large sheets.

The evidences of the action of icebergs or floating ice

observed by Sir William Dawson[1] and the writer[2] are chiefly in the St. Lawrence valley and on the Baie des Chaleurs coast. In the former the markings produced by these occur, so far as I have observed them, only on rock surfaces below the 350 to 375 contour line above sea level, while on the coast of the bay referred to they were not seen higher than 200 feet above its surface.

Icebergs or drift-ice played an important part in striating the ledges on these lower levels and in transporting boulders. On the isthmus of Chiegnecto the striation of some rock surfaces is attributable to them.[3]

The facts briefly outlined in the foregoing pages will doubtless receive large additions within a few years ; and the inferences deduced therefrom may consequently undergo some modifications as the glacial phenomena of the region comes to be studied in detail. This remark has reference more especially to the glaciation of the great Laurention or Archæan Area. I venture to think, however, that the main conclusions herein advanced will stand.

Newfoundland.

Newfoundland, although not forming part of Canada is geographically connected with it and a passing reference may here be made to its glacial phenomena. According to the late Alex. Murray, C.M.G., Director of the Geological Survey of that Colony, its surface every where shows marks of glacier-ice.[4] These are well described in the paper referred to below. Mr Murray held to the theory of a continental glacier, however, but his facts indicate that ice movements have been quite variable, following river valleys,

[1]Acadian Geology, 2nd and 3rd eds. Notes on the Post Pliocene Geology of Can., 1872, *Can. Naturalist*, etc.

[2]Annual Report Geol. Surv. of Can., 1886, Vol. II., part M. Transactions of the Royal Soc. of Canada, 1886, in a paper on *The Glaciation and Pleistocene subsidence of Northern New Brunswick and South-Eastern Quebec.*

[3]Annual report, Geol. Surv. of Can. 1885, Vol. I, part G.G.

[4]Glaciation of Newfoundland. Transactions of Royal Soc. of Canada, 1882.

depressions, etc., in several directions. It seems probable therefore, that here, as in Eastern Canada, local glaciers descending from the higher gathering grounds towards the coast, as pointed out by the late Capt. Kerr, R. N.[1] were the principal agents at work. But from its insular position, and lying as it does in the track of the Arctic currents, the coastal areas, at least, must have been subjected to intense erosion from icebergs and floating ice.

The Food of Plants.[2]

By D. P. Penhallow.

An old proverb informs us that one-half of the world continues in ignorance of how the other half lives. If we accept this in the broadest sense, as applying to all organic life, we have a present illustration of its correctness in the fact that, with few exceptions, man knows little or nothing of the vital processes upon which the growth of the members of the more humble vegetable kingdom depend; and he thus fails to grasp a knowledge of those important laws by which plants are enabled to afford him an abundance of sustenance and raiment. It is in relation to purposes of nutrition, that plants may be considered to bear the greatest importance to man, and in this respect, they are to be regarded from a two-fold point of view.

First, they convert the crude mineral constituents of the soil, which would otherwise be wholly unavailable, into forms which enable them to become of direct value for purposes of animal nutrition. They thus afford to man, his principal supply of food. But they also constitute the entire source of nourishment for those animals upon which man subsists, and through the medium of which they undergo further special modifications, by virtue of which

[1] Ibid, p. 68.

[2] Sommerville Lecture delivered March 28th, 1889.

they become yet more fully adapted to special requirements of the human system. Man is therefore dependent upon plants as the great preparers of his food, both directly and indirectly.

With a more thorough knowledge of animal nutrition, we have come to recognize more generally than in the past, that the quality of the food supply effects a pronounced and most important influence upon both the physical and mental condition, and this influence must be exerted both directly and indirectly by the vegetation upon which man feeds. We are therefore brought to yet another principle, that any improvement in the character of the food supply, must operate advantageously for man, in a corresponding systematic improvement.

But the great biological laws are not adapted with sole reference to particular forms of life—they admit of general application, and, as we learn from vegetable physiology, the character of the plant is subject to the influence of variable nutrition, in a manner quite parallel to that which we observe in animals. In this, therefore, we discover the possibility of a means of making plants more perfectly adapted to the highest physical wants of man, and any study which tends to promote this end, cannot fail to be of the greatest interest, bringing us, as it inevitably must, into closer relationships with those forms of life upon which we are so largely dependent for health, comfort, and enjoyment.

The subject we have chosen for discussion this evening, is one of considerable magnitude—embracing considerations of the greatest practical and scientific interest—and could readily be dealt with from several points of view. Perhaps many would consider that a mere statement of the articles which constitute plant food, together with the fact that the earth and air are the great sources of supply, would fully exhaust the subject, but an enlarged view discloses the fact that the sources of food supply; the preparation of food for the use of the plant; the general process of waste and repair; the selective power of plants

in relation to food supply; the number, character and special functions of the elements appropriated; the relations of food supply and nutrition to conditions of health and disease; the relations of food supply to improved qualities of plants for purposes of human food; the special capacity of the plant for digestion, and its relation to the character of food used, are all so intimately connected with the subject as a whole and with each other, that no complete statement can be made without taking some account of all these considerations. Concerning some of them, we are forced to admit that as yet, but little real progress has been made in the direction of their correct elucidation, nor can we look for a final solution until such time as chemistry shall make us more fully acquainted with the composition of plants in various stages of development, and under widely different conditions of growth, and thus provide the key which shall unlock the door to those now mysterious physiological changes peculiar to nutrition.

In the process of nutrition, certain substances enter directly into the composition of various parts of the plant, to the formation of which they are absolutely essential. There can, therefore, be no doubt that they are food substances. Others, however, although taken into the plant, do not enter as an essential ingredient into the construction of parts. Nevertheless, it is found that their elimination from the food supply so disturbs the normal processes of growth, as to leave no doubt in our minds concerning their necessity in what are termed the metabolic processes, or the chemical changes incident to nutrition. It is therefore as proper to regard them as food substances as the former.

In order to determine what elements may be properly regarded as plant food, we first of all resort to chemical analysis, and in the second place to special methods of cultivation. When a plant is burned, or when it suffers the slower oxidation of decay—the final results being the same in each case—we find that by far the greater part of the original structure disappears in the form of aqueous vapor, carbon dioxide gas and volatile acids, while a very small

proportion remains as an unoxidisable or incombustible residue—the ash.

The relative proportions of combustible and ash constituents, are subject to wide variations, not only as between different species, but even in the same species under different conditions of growth and of food supply, An illustration of this law may serve to make our statement more clear. In the Tenth Census Report of the United States for 1880, Prof. Sargent gives the ash percentages for somewhat more than four hundred species of woods. Selecting from these the extremes, we find the following:—

	Org. Mat	Ash.
Yucca elata..............................	90.72	9.28
Pseudotsuga Douglassii................	99.98	0.02

Again, between these and herbaceous plants, in which relatively less mineral matter is observed, the difference would be more striking, Another illustration of the law stated, is afforded by the results obtained by Arendt in his analysis of 1000 oat plants selected at different periods of growth, with intervals of about twelve days. His results were as follows:—

	June 18. 3 leaves open.	June 30. Heading.	July 10. Blossoming.	July 21. Ripening.	July 31. Ripe.
SO_3............	1.06	2.71	2.68	4.83	5.34
P_2O_5...........	3.27	5.99	10.32	12.90	14.23
K_2O...........	17.05	31.11	40.20	44.33	43.76
Ca O...........	4.48	8.50	11.60	14.94	14.71
Mg O...........	1.53	2.71	3.71	5.42	6.45
Fe_2O_3..........	0.20	0.46	0.61	0.83	0.58
SiO_2............	6.39	15.82	25.45	34.66	36.32
Na_2O...........	0.86	1.28	1.47	1.12	0.87
Cl.............	2.28	3.62	5.32	5.96	5.78
Total grammes...	37.12	72.20	101.36	124.54	128.04
Gain for each period........		35.08	29.16	23.18	3.50

If we now turn our attention more particularly to the elements of the first group, or those which disappear in the process of combustion, we find them to be carbon, hydrogen, sulphur, nitrogen, phosphorus, oxygen and chlorine. In the process of rapid combustion, the hydrogen is converted into water and passes off as aqueous vapor. The carbon becomes changed into carbon dioxide—a gas prejudicial to animal life—and disappears in part into the surrounding atmosphere, the remainder being fixed in the ash residue, where we also find the acids of sulphur, nitrogen and phosphorus combined with the mineral constituents to form the corresponding salts. In decay or slow combustion, the same changes are finally accomplished, with the additional formation of volatile sulphur and ammonia compounds. The loss or diminution in volume which a plant suffers in the process of combustion, will thus be seen to correspond, in general terms, to the elimination of the organic matter, which consists almost wholly of carbon, hydrogen and oxygen, with very small quantities of the other elements mentioned.

If we next inquire into the composition of the second or incombustible group, we find it to contain potassium, sodium, calcium, magnesium, iron and silicon. These elements, as already stated, are found in combination with the acids derived from combustion of the elements of the first group. In exceptional cases, manganese, bromine and iodine, as well as arsenicum, copper and other metals may be found in the ash, but for various reasons which need not be dealt with at the present time, they are usually not regarded as constituting elements of plant food. It thus appears that of the sixty-seven chemical elements known to science, only thirteen are to be regarded as of importance in the economy of the plant.

With these general facts before us, we are now prepared to inquire into the sources whence they are derived; and in this respect we may again divide them into two groups, those derived from—1st, the air, and 2nd, the soil.

To the first group belong only two elements, carbon and oxygen. These are presented to the plant and taken up in the form of carbon dioxide. Oxygen is also absorbed in the free state, but in this respect it is concerned in the process of respiration, and not of digestion, and therefore is not to be considered in the present connection.

Carbon dioxide is, as we know, a peculiar product of organic combustion, including respiration of both plants and animals, and when produced in excess, is as prejudicial to one form of life as to the other. Its elimination from the atmosphere in the process of vegetable growth, constitutes one of the most important relations in which plants stand towards the higher forms of animal life. During the Carboniferous age, when life was of a much lower type than now generally exists, plants attained to a luxuriance of growth with which but few modern plants can compare, and while this was the direct result of the peculiar conditions under which they were placed, it also adapted them to the more rapid elimination of carbon dioxide—thereby causing a return of oxygen to the air, and a fixation of the carbon, which, in course of time, became transformed into coal and graphite as we find them to-day. Thus the atmosphere became adapted to an improved type of animal life; the plants themselves, being brought under new conditions of environment, suffered important changes, and man is now enabled to convert to his own needs the transformed energy derived from the sunbeams of that remote past.

To the second group of elements, those derived from the soil, belong all the others that have been enumerated. It should be observed here, however, that oxygen is also derived from the soil, both as water and as acids in combination with the earthy elements.

The appropriation of food is provided for by means of specialized organs. The gaseous elements of the air are absorbed by the leaves, in which specialized openings or mouths, called stomata, are developed. Through these, the gases of the atmosphere penetrate the interior structure by a process of diffusion, and are there absorbed by the living

cells. It is of interest to note, however, that the ability of plants to use the gases which have thus penetrated their structure, is dependent upon certain important conditions, viz:—1st, a favorable temperature, (2) the presence of the ordinary green coloring matter of plants—the chlorophyll—and (3) the direct influence of sunlight, or at least of its luminous rays. Neglecting further consideration of temperature which is essential to all functional activity, it should be pointed out that plants devoid of chlorophyll, such as mushrooms and other colorless plants, are incapable of obtaining carbon from the atmosphere. They are therefore forced to obtain their supply of this important element either from other plants upon which they feed as parasites, or from the organic products of decay, upon which they feed as saprophytes. Moreover, the power of green plants to appropriate carbon and liberate oxygen is arrested under conditions of darkness—as at night—when the mode of growth is precisely the same as in colorless plants.

The whole relation of light to the appropriation of carbon, is one of the most interesting with which the physiologist has to deal, but it would lead us too far from our present purpose were we to consider it more in detail, though it may be as well to point out that, if ordinary white light be replaced by such luminous rays, as the orange and yellow, this function is not impeded in any way; while on the other hand, the rays of higher refrangibility such as the blue, indigo and violet, arrest this function and thus bring ordinary green plants under abnormal conditions of growth, in which functional disturbance is the unavoidable result.

In this particular connection, it only remains for us to indicate what changes take place when carbon dioxide is taken up by the leaves. Under the influence of chlorophyll this gas suffers decomposition. The liberated oxygen returns to the atmosphere, while the carbon, uniting with the elements of water already present, becomes transformed into starch, sugar and oils,—substances which not only provide for the nutrition of growing parts, but, when formed in

excess of the requirements of growth, supply a most important item of food for man.

Various observations have been made to determine the amount of carbon dioxide which plants are capable of appropriating. The results obtained by Boussingault are among the most instructive, from which we quote the following:—

	Area of leaf.	Decomp. of CO_2 per hour.
Cherry-laurel....	109 sq. c.m.	3.0 c.c.
Pine............	204 " "	1.1 "
Oak.............	224 " "	1.6 "
Holly	52 " "	1.8 "
Mistletoe.......	100 " "	2.0 "

or for equal areas

Cherry-laurel....	100 " "	2.750 "
Pine	100 " "	0.539 "
Oak	100 " "	0.714 "
Holly...........	100 " "	3.460 "
Mistletoe	100 " "	2.000 "

In this connection it should also be noted that the presence of carbon dioxide in the air, beyond a certain limit, causes it to exert a deleterious effect. This limit is of necessity variable, but observation has shown that in those plants which are most nearly allied to the coal plants, e.g., ferns, ten per cent. is fatal, while for the majority of plants, a much smaller quantity will produce the same result. The general process thus described, constitutes one of the leading features of the so-called digestive function, and as this takes place in the leaves (chiefly), they are usually designated the digestive organs.

All the elements enumerated, except carbon, enter the roots which are specially adapted to the purpose of taking up food in a liquid form, and may therefore be designated the special organs of absorption. The power of roots in this respect, is nevertheless extremely limited with reference to their total area, being confined to a narrow tract near the extreme tips, and is accomplished chiefly through the medium of root hairs.

The fluid thus absorbed by the roots, and containing various

mineral substances in solution, now constitutes what is commonly designated the crude sap, inasmuch as the substances held by it are not in such chemical condition as will enable them to directly participate in the nutrition of growing parts. This sap, however, passes upward through the outer layers of the woody tissue or sapwood, until it reaches the leaves, where it is distributed among the ramifications of the veins to the active, chlorophyll-containing cells, in which it becomes involved in the process of digestion. In the course of this process it suffers increase of density, due in part to the fact that a large portion of water is liberated as aqueous vapor into the surrounding air, while another volume is used up in the various chemical changes, and the fluid, now distributed from the leaves to the various centres of active growth, is said to be digested and capable of directly promoting the formation of new structure.

Although plants in general may be said to be the special agents whereby the crude material of the soil and air is converted into that which is of direct value in animal nutrition, yet we find the law subject to certain important exceptions, since in their power of appropriating and converting food, they exhibit a wide difference.

We are all familiar with the fact that in the animal kingdom, certain forms live upon and draw their entire sustenance from other animals, in consequence of which they are termed parasites. Parasitism is also a common feature of plant life, and in each case the relations of supply and demand conform to the same general laws. The parasitic plant fastens itself upon its host and draws its nourishment from it. The latter is therefore forced to yield a portion of the food prepared for its own use, and in consequence of this unusual demand upon its resources, it sooner or later becomes diseased, exhibits malformations and may eventually be killed. Under these conditions of growth the parasite does not require to produce its own food; we therefore find that it has no roots, its leaves are imperfectly formed, and it may contain no chlorophyll. Just in proportion, therefore, as the

digestive function of such plants is reduced, do they become incapable of fixing carbon and forming the ordinary carbohydrate products such as starch and sugar. Some of the most notable of parasites are to be found in the celebrated banyans of India, which often begin their growth in the tops of lofty trees, upon which they feed until killed.

We again find a very large class of plants feeding upon the products of organic decay. These contain no chlorophyll, have no proper roots and no leaves, or at most mere rudiments of such organs. Like the parasites, they cannot appropriate carbon, except in the form of organic compounds; their existence thus implies their dependence upon previous life. They do not liberate oxygen, but eliminate carbon dioxide as one of their characteristic products. Such plants are designated by botanists *saprophytes*, and are represented by the mold of stale bread and cheese, by the common mushroom and puff-ball, and also by the Indian pipe, one of our common wild flowers.

We thus find that any extended consideration of the subject with which we are now dealing, must recognise the special characteristics of plants in their relation to the appropriation of food, but as more detailed statement would lead us too far from our main purpose, we shall for the remainder of our discussion, confine ourselves to those plants in which the digestive function is fully developed, and with which we are more largely concerned as the producers of our food.

The special functions of the various elements appropriated by the plant, are not at all well understood, but the results of investigations so far made, indicate their value in a general way and show in what direction other inquiries should be made. For the purpose of determining how far each element present is essential to growth, we resort to special methods of culture, either in water or pure quartz sand, under such conditions that the number of elements and the exact quantity of each may be known and controlled.

From such a series of investigations we learn that potash

is absolutely indispensable; that under certain circumstances, soda may be eliminated without injury; that iron is essential to the formation of chlorophyll; that calcium performs a function somewhat similar to that of the potash; that it may to some extent replace it, and that it is possibly connected with the formation of tissues; that chlorine, and in some cases, sulphuric acid, is essential to the proper transfer of the substances digested in the leaves, to the parts where required by growth; that magnesium is an element of uncertain value in the internal physiological processes, but that it has a definite value in the soil, where it aids in the distribution, and thus in the more complete appropriation of potash; that silica cannot be eliminated without materially affecting the strength of the plant, and that phosphorus bears an important relation to the various processes of ripening in the fruit.

Another very important lesson to be derived from such special cultures, especially when combined with chemical analysis, is the fact that plants exercise a selective power with reference to the food supply; that is to say, if a plant were grown in a solution containing exactly the same proportions of all the elements entering into its composition, it would be found not to absorb them all in the same quantity, but some would be used much more largely than others. This becomes more obvious if we inspect the composition of the ash of different plants, or even of the same plant under different conditions or at different stages of growth.

It thus appears that some plants are special potash feeders, others use more lime, yet others an excess of soda, and this fact constitutes the foundation on which the well known system of rotation of crops is based. This briefly stated, is as follows:—When plants are grown continuously upon the same piece of land for a number of years, those elements upon which that particular class most largely feeds, will be withdrawn in excess of the ability of the soil and the natural chemical processes there taking place, to restore them. The soil is therefore said to suffer special exhaustion, because it is deficient in one or two elements

required for a particular crop, but contains an abundance of other elements required by other crops. If these latter are now planted, the soil, in course of time, suffers special exhaustion with reference to their requirements, while it regains its ability to produce the crop of the first kind. Thus, by a judicious system of rotation, land may be kept in a constant state of productiveness. It is only when food elements are so completely withdrawn that no one class of plants can be brought to perfection, that the soil is said to be generally exhausted. Therefore, when we speak of the fertility of a soil, or the exhausted condition of a soil, it must always be with direct reference to the particular requirements of the plants we wish to cultivate. And I cannot let this part of my subject pass without pointing out that a large part of the difficulty in successfully combating some of the most destructive diseases of the orchard and garden, arises from a failure to properly appreciate and apply the principles stated.

It is impossible to give more detailed consideration to these aspects of our subject in the brief space allotted to us, important though they are. There are, nevertheless, two features of this question to which I would particularly draw your attention, and from their very important bearing upon the economic side of horticulture, I feel that their somewhat detailed statement will not be out of place. I refer, in the first place, to the relation of nutrition to conditions of health and disease; and in the second place, to the relation of nutrition to improved qualities of fruits.

For many years, the Germans have been among the foremost investigators in efforts to determine the special functional value of the various food elements of plants. The method usually selected has been that of water culture already described, through the medium of which the effect of eliminating any given element, or of varying its proportion and particular chemical combination in the food supply, could be accurately ascertained. From a series of such experiments made as long ago as 1871, in which buckwheat was the particular plant employed, it was observed that in

those plants from which potash was eliminated, there was a most marked deficiency in growth. This was traceable to the fact that in the absence of potash, the plant was incapable of fixing carbon, and therefore unable to produce the ordinary products of digestion, such as starch, sugar and oils, and hence was practically in a condition of starvation. In a second series of experiments, potash was supplied in the requisite quantity, but chlorine was eliminated from the food supply. A most curious result was found. While an abundance of starch was produced in the first instance, it was unable to reach those parts where growth was most active, and thus became accumulated in unusual quantity in the leaves and other green tissues where formed. A secondary effect of this was a change of color from green to yellow, whereby the further formation of starch was arrested, and the final result was a general arrest of growth. So that there was established the anomalous condition of a plant containing an excess of tissue-forming material, but unable to use it for want of a certain element in the food supply, which would effect a transfer of that material to the centres of active growth. Further observations confirmed the view that chlorine was the particular element needed for this purpose.

Acting upon the suggestions contained in these results, Dr. Goessmann, the foremost agricultural chemist in the United States, and Director of the Massachusetts Experiment Station, a few years since, in company with other investigators, undertook to apply these principles of nutrition to the treatment of certain diseases of plants, which, up to that time, had baffled all attempts at control, and which, in the seriousness of their operations, threatened to destroy some of the most important fruit interests of the country.

It was found, in the first place, that in the common and destructive disease known as Peach Yellows, there were conditions of growth in all essential respects the same as those artificially produced in buckwheat by elimination of chlorine. It was therefore assumed for the purposes of ex-

periment, that this element was exhausted from the soil and that potash might also be supplied in insufficient quantity. A number of trees were therefore carefully pruned to remove as much as possible of the diseased structure, and muriate or chloride of potassium was supplied to the trees as a special food, together with other elements to make a complete fertilizer. It was now found that the new growth was of a totally different character, and, so far as could be determined from mere external inspection, perfectly healthy. But more than this, the fruit, instead of being utterly worthless, as before, now became of high quality, and the life of the tree was so far prolonged that, instead of dying at the end of nine years, as was usually the case, the identical trees thus restored to health are bearing first quality fruit to this day, or twenty years after their period of first treatment.

But this result alone, important as it is, does not fully answer the question from a scientific point of view, and we are therefore called upon to see what changes, if any, were effected in the chemical constitution of the ash, and also in the cellular structure and distribution of the digested products. With reference to the first, the results are most significant, and tend to indicate that the supply of potash bears a direct relation to the normal condition. Thus Goessmann found the ashes to be constituted as follows:

	Fruit.		Wood.	
	Diseased.	Healthy.	Diseased.	(Restored.) Healthy.
Fe_2O_3	0.46	0.58	1.45	0.52
CaO	4.68	2.64	64.23	54.52
MgO_2	5.49	6.29	10.28	7.58
P_2O_5	18.07	16.02	8.37	11.37
K_2O	71.30	74.46	15.67	26.01

From this it also appears that, with a deficiency of potash, lime increases, but does not replace it in functional value.

Referring now to the internal structure, we also find most important changes accomplished. In the diseased

tree, the general structure of the bark becomes altered in a conspicuous manner, while in both bark and leaves, the accumulation of starch is most unusual. These features are so characteristic of the disease, and appear so early in its development, that a correct diagnosis may be made through the aid of the microscope, even before the external evidences of disease are pronounced. In the new wood formed after treatment, the bark presents all the features of normal structure, both with reference to tissue and distribution of starch.

We thus note certain important facts as the result of these experiments :

1st. That a specific disease is cured by a certain course of treatment.

2nd. That potash and chlorine are essential to restored functional activity.

3rd. The disease may be regarded as primarily due to deficiency of these elements in the food supply.

But we should also point out that for this disease, any salt of potash will not answer, *i.e.* the sulphate or the phosphate will not be equally efficacious with the muriate, but that does not permit us to infer that diseases of other plants may be similarly cured by the same salt of potash, for on the contrary, the same investigations have shown that for different plants, different salts of potash must be used, so that while in some cases the chloride is best, in others it is the sulphate or nitrate.

We have here, however, a definite fact established, namely, that the nutrition of the plant bears a most important relation to its normal condition, and while we do not wish to rashly assert that all diseases to which plants are subject may be cured in this way, yet we do feel confident that, when the bacteria craze has passed its fever heat, and the pulse of the investigator has once more returned to a normal rate, he will turn his attention more fully to the question of nutrition as affording a rational explanation of many of the vexed problems which now confront him.

Before taking final leave of this part of our subject, I will

point the general principles indicated by one more fact. The ravages of the Phylloxera have for many years proved a most serious obstacle to the successful cultivation of the vine in many parts of Europe, and the French Government have at various times had their attention seriously drawn to the devastations of this insect; but the efforts thus far made, appear to have led to no very substantial results. In the course of investigations relative to the nutrition of the grape, Dr. Goessmann found that an abundant supply of food of an available form, served in a most marked degree to overcome the ravages of the Phylloxera. The results were of so striking a character as to attract the attention of the French Commissioner then inspecting the vineyards of the United States, and he freely expressed the opinion that, although the vines were fairly over-run with the pest, he had never seen more healthy looking foliage, better growth or finer looking fruit. The whole principle underlying this result is that, if we can feed the plant, and at the same time provide an abundance of food for the parasite in excess of what the plant needs for its own growth, the latter will be much less liable to suffer.

In conclusion, I would direct attention to one more of the many interesting aspects which this subject presents, and that is the relation of nutrition to improvements in plants, and more particularly of their fruits or seed bearing parts—those products of the vegetable world which are of the highest value to man as articles of diet.

We commonly speak of plants as cultivated and uncultivated or wild, and in doing so we make a broad distinction even between plants of exactly the same species. This distinction is that, under certain improved conditions of life, the plant has become so modified as to present peculiarities which it did not possess in the wild state, while it also has an increased capacity as a food producer. Such a change, under the ordinary conditions of cultivation, is in most cases a very slow process, but as an essential factor, we recognise the supply of food of better quality and in more available form—in general terms, improved conditions

of nutrition. Science has repeatedly shown that an increase of sugar percentage in the beet, or of starch in the potato, is directly related to the supply of potash to the plant and the condition of availability in which that element is presented, and the question has therefore more than once been asked,—is it not possible by a judicious control of the food supply, to bring about, more quickly, those changes which are known to have taken place between the wild and cultivated plants, and in the latter to still farther improve their qualities? I think the results so far obtained justify us in answering this question in the affirmative, but before so doing, I must briefly refer to the relative value of nitrogenous and non-nitrogenous food substances in the two phases of growth through which all plants pass, namely, the purely vegetative, or that period during which mere extension of parts, as stem and leaves, takes place; and the reproductive, or that period in which the flowers are produced and the seed is formed for the growth of succeeding generations. The elaborate series of investigations conducted by the Germans for many years, as well as the very notable investigations of Lawes and Gilbert at Rothamstead, England, in which continuous observations have been made upon various field crops grown on the same land and under the same conditions since 1835—all these results establish the general law that those foods in which nitrogen is in relative excess, promote the mere extension of structure and tend to retard the reproductive function. While on the other hand, those foods in which the mineral substances are in relative excess, tend to retard vegetation, induce an earlier maturity, and thus hasten the formation of seed. Probably many of you have observed how a plant fed with ammonia makes a most vigorous growth of leaf and branch, and acquires a deeper and richer hue, and how also, trees are similarly influenced when located in exceptionally rich places. A notable illustration of this was brought to my notice a few years since. The ground in a small peach orchard was utilised as a kitchen garden, and for this purpose annually received a heavy dressing with nitrogenous

manures. The effect upon the trees was most marked. The leaves were of an unusual size and depth of color, and the growth of each year was far in excess of any other trees. But, although twelve years old at the date of last observation, and thus nine years older than the age at which fruit should be formed, they had not produced a single peach, nor did there appear to be any likelihood of their doing so. In other words, under the special conditions of growth established, the fruit producing function had been wholly arrested, and the trees were therefore worthless. A remedy for this would be found in a reduction of the nitrogenous foods, and a greater supply of mineral foods. A still further application of this principle will probably permit us to bring fruits to maturity more perfectly than now, and also enable us to overcome the disastrous effects of early frost where trees tend to continue their growth too late in the season. These facts therefore suggest one important direction in which these laws of nutrition may be applied.

We will now turn our attention more particularly to a consideration of improved varieties and the relation of such improvement to the composition of the ash, and in doing so we shall make use of results obtained by the investigator already quoted. The fruit of the wild strawberry (*Fragaria vesca*) contains, according to the analysis of Richardson, 0.41 per cent. of ash. In this we find

Potash	22.06
Soda	29.79
Lime	14.88
Magnesia	traces
Iron	6.07
Phosphoric acid	14.47
Silica	12.62

this calculation being made after deducting sulphuric acid and chlorine, for reasons which need not be specified at the present time.

As determined by Goessmann, the fruit of the cultivated

strawberry contains from 0.41—0.63 per cent. of ash, and this includes.

Potash	40.24
Soda	3.23
Lime	13.47
Magnesia	8.12
Iron	1.74
Phos. acid	18.50
Silica	5.66

A comparison of these figures shows that under the ordinary conditions of cultivation, the plant utilises much less silica, iron and soda, but makes greatly increased demands upon potash, magnesia, and phosphoric acid. In view of these facts, it can hardly be doubted that these elements are essential to a higher state of development, more especially as we observe that when the conditions of cultivation are reduced and the supply of these elements is diminished, the plant reverts to its original condition, both with reference to its general characteristics and the chemical constitution of its ash. These changes may be regarded as effected slowly, as in the ordinary transition from the wild to the cultivated forms. Let us now see how the special application of food will influence a similar result. An exhaustive statement of the results obtained by Goessmann cannot be made here, but the following are the essential facts.

Observations were made upon the Concord Grape as a cultivated variety, and upon the *Vitis labrusca* as the wild species from which the Concord originated. In each case certain plants were grown without special fertilisers, while others were treated with fertilisers of three separate combinations. With these latter we will not deal separately, as we desire now to discuss only the general results.

The ash of the Concord Grape was found to contain when unfertilised

	Sept. 13.
Potash	57.15
Soda	4.17
Lime	11.30
Magnesia	3.10
Iron	0.40
Phos. acid	12.47
Silica	11.83

In the ash of the fertilised grape there were

	Oct. 3.
Potash	64.65
Soda	1.42
Lime	9.13
Magnesia	3.63
Iron	0.50
Phos. acid	14.87
Silica,	5.80

But these changes in ash composition are found to be directly associated with an increase of sugar, a decrease of free acid and a general improvement in the quality of the berry.

Turning now to the wild grape, we find at the end of four years growth, that changes in the ash, were accomplished as indicated by a comparison with the ash constituents of the uncultivated wild grape:—

	Unfertilized.	Fertilized.
Potash	50.93	62.65
Soda	0.15	0.85
Lime	22.23	14.24
Magnesia	5.59	3.92
Iron	0.79	0.53
Phos. Acid	17.40	13.18
Silica	2.93	4.63

While the organic matter stood in the following relation:

Organic matter	16.31	19.55

and this striking increase was found to relate chiefly to an increased percentage of sugar and reduction of acid in the juice as follows:—

Sugar	8.22	13.510
Acid	9.84	1.149

Thus as the direct result of special feeding, the sugar percentage of the wild fruit is increased from eight to thirteen per cent., a quantity nearly as great as that found in the cultivated Concord Grape at the same season.

The significance of these results must be apparent to every intelligent cultivator, and to quote the words of the investigator above cited, "The ability to effect such decided

changes in the composition of our fruits, cannot but be of the greatest importance to horticulturists in improving the the quality of the new cultivated varieties, and in producing new varieties of a desired quality. If we can change the composition of our fruits in one or two elements, by the application of the proper food, why cannot we change the proportion of any element? In the seed is stored up the element of the new plant, and the varied compositions may be accompanied by certain physiological changes which shall determine the character of the variety."

My object for presenting the facts to which I have called your attention this evening has been, not to bring forward any detailed exposition of scientific observations, but rather to draw your attention more prominently to the general principles underlying the laws of growth and nutrition, and to show that our modern horticulture has entered upon an entirely new phase, in which scientific observation is the basis; and he who wishes to reap the large benefits to be derived from the intelligent pursuit of horticulture in any one of its important branches, must recognize the necessity of securing for himself, as a necessary preliminary to his work, an accurate, though general scientific culture. If my object in this respect be gained, even in a remote degree, the law of compensation may be considered as having found its application.

GYPSUM DEPOSITS IN NORTHERN MANITOBA.

By J. B. TYRRELL, B. A., F. G. S., *of the Geological and Natural History Survey of Canada.*

On the Little Saskatchewan River, which carries the overflow of Lake Manitoba into the western side of Lake Winnipeg, there is a comparatively small shallow lake which has been known since the time of the early voyageurs as Lake St. Martin. It lies in latitude, 51° 30′, longitude, 98° 40′, has an area of 115 square miles, a greatest depth of about fifteen feet, and an approximate elevation above the sea of 790 feet.

Lying to the north-west of this lake, there is an area of level or very gently sloping country, which is now covered by extensive natural meadows, separated by groves of poplar and birch, as well as occasional forests of spruce and tamarac. This country is as yet in its native beauty, being entirely untouched, either by the woodman's axe or the plough of the farmer; but the time cannot be far distant when a thriving agricultural population will occupy the district, reaping from the fertile soil bountiful and continuous harvests.

In the early part of the past summer, the writer made a short journey on foot into this country, from the shore of the lake, in order to determine the question of the existence or non-existence of beds of gypsum in the vicinity.

Starting from the north-west corner of the Indian Reserve at present held by the Saskatchewan Band of Saulteaux Indians, we travelled in a general north-westerly direction for five miles, till we reached a rounded gravel ridge, rising from fifteen to twenty feet above the general level of the country to the north-west of it, and along the foot of which, on the alluvial plain, are scattered numbers of rounded, weather-worn, gneissoid erratics. This ridge represents a beach of the extended Lake Winnipeg, called by Mr. Warren Upham Lake Agassiz, when it covered the whole of this area, and when the surrounding fertile alluvial deposits were being laid down near its gradually receding shore. The height of this ridge, as shown by aneroids read simultaneously on it and on the lake, is about 840 feet, being fifty feet above Lake St. Martin, and thirty feet above Lake Manitoba. Its chief interest, however, did not centre in the fact that it had once represented a lake-shore line, for these shore-lines are very commonly to be met with in all this apparently level Manitoba plain, but that in little holes and caves in it were to be seen small exposures of soft, compact, snow-white gypsum.

Following the ridge, still in a north-westerly direction, for a mile, the surface becomes very rugged and irregular, being broken by deep pits with steeply sloping sides. In

this rough country, gypsum may be seen in numerous outcrops, being usually soft and crumbling from the effect of weathering, but in some cases it is still quite hard. The height of the tops of the knolls in this hilly area is about thirty-five feet above the eastern level plain, or sixty feet above Lake St. Martin. The breadth of the hilly country was not determined, but an Indian who accompanied us stated that it extended in a south-westerly direction, as far as a certain point on our journey of that day, which was about a mile and a half distant from where we were then standing, beyond which the level country began again.

In a north-westerly direction the ridge was followed for two miles further, to a rather conspicuous hill a short distance north of the Ninth Base Line in section 2, township 33, range 9, west of the Principal Meridian. In this distance it appeared to be broken through by considerable gaps in several places, but where it was well marked, it invariably showed the irregular surface so characteristic of country underlain by gypsum deposits. In many places, small caves would extend in from the bottoms or sides of the pits, some of which held beautifully clear, cold water, a luxury of which we were able to appreciate the value, after tramping for the greater part of a sweltering July day through meadows, forests and swamps, where the mosquitoes and black flies did not attempt to treat us any the more tenderly because we were strangers.

This country is a famous winter hunting-ground for the Indians, for in the autumn the bears retire to these caves, as being comfortable quarters in which to pass the time until the following spring, and many of them are killed every year. Around the mouths of several of the caves could be seen marks of the axe, where the hunter had been obliged to widen the entrances to the cave to be able to get into it to secure his prey. The thickness of the exposures of gypsum in these holes and caves was nowhere very great, ranging as a rule from three feet to six feet six inches, but in none of them was the total thickness of the deposit seen.

The hill at the furthest point to which the ridge was fol-

lowed, rises as a rounded knob, twenty feet above its general level. This hill, like the others, appears to be composed of gypsum, as on its sides are holes extending down twenty feet below its top in which beds of gypsum are well exposed.

In the north-west corner of township 32, range 8, west of the Principal Meridian, is a rounded hill rising thirty-five feet above the plain, its greatest length being about 600 feet, and its greatest breadth 150 feet. Its surface is overgrown with small canoe-birch. Two holes, each about eight feet deep, have been dug by prospectors in this hill. One at the top shows, below a foot of decomposed material, seven feet of hard, compact, white anhydrite or "bull plaster," exhibiting a more or less nodular structure, and breaking on the surface into small irregular fragments. Very little bedding can be detected in the mass. The other hole is in the side of the hill fifteen feet lower down, and shows on top two and a half feet of white clay, consisting of decomposed anhydrite, below which is five and a half feet of white nodular anhydrite similar to that in the other hole. This gives a thickness, almost certainly, of twenty-two feet of this rock, and it is not improbable that the hill is composed entirely of it.

Again, just north of the Ninth Base Line, and two miles east of the township corner, between ranges 8 and 9, is a poplar-covered hill or ridge, thirty feet high. In various places on this hill are exposures of snow-white gypsum, similar to what has been described above, showing in some cases a thickness of ten feet in one section. The most of it is massive or crypto-crystalline, and lies in regular beds which dip slightly towards the west. Some of the beds or layers, however, consist of beautifully crystalline, clear, colourless selenite, which is easily broken out in lamellar masses of considerable size. This is the mineral which in the west, has been so often mistaken for mica.

The above is a brief statement of the known extent of the deposits of gypsum in this district, but it is highly probable that further investigation will prove them to extend over a much larger area. The Indians of the

Saskatchewan Band, who live on the western shore of Lake St. Martin, informed me that similar rock was to be found in several places further north, and they have named a lake on a tributary of Warpath River, which flows into Lake Winnipeg north of the mouth of the Little Saskatchewan, Ka-ka-wusk Sa-ka-higan (translated in English as Mica Lake) from the alleged presence of selenite in its vicinity.

Towards the south-west, at a distance of ninety miles in a straight line, in the bore that was sunk on the bank of Vermilion River by the Manitoba Oil Company, a bed of gypsum fifteen feet in thickness was struck between 550 and 565 feet, at approximately the same geological horizon as that of the gypsum beds above described. Gypsum deposits are therefore in all probability very widely distributed throughout Northern Manitoba.

As far as examined they preserve a pretty constant character. Where they immediately underlie the surface the country is very rough and hilly, and the prevailing poplar of the region is mixed with birch, or the spruce of the adjoining low-lying land is replaced by Banksian pine. The gypsum itself is generally very pure, of a dead white colour, and usually stratified in rather thin beds, which are either horizontal or dipping at a low angle. Among the massive beds, however, are many others, composed of crystals or crystal-masses, in which the crystals usually stand transverse to the plains of bedding. Some plates could doubtless be obtained from the crystal-masses sufficiently clear for optical purposes. No anhydrite was seen mixed with the gypsum, but one of the hills, as above stated, appeared to be composed entirely of it. It is much harder and tougher than the gypsum or hydrated sulphate of lime, is considerably heavier, has a roughly nodular, rather than a distinctly stratified structure, and is of a decidedly bluish tint.

Of the exact geological age of the deposit it is difficult to speak as yet with certainty, as the strata have not been continuously traced into any others, and no beds im-

mediately under or overlying them have been seen. There is little doubt, however, that they occupy either the summit of the Silurian or the base of the Devonian limestones. All the evidence that we have on the point has not as yet been perfectly elaborated, but it consists in the general horizontality of the beds wherever seen throughout the whole area, and in the existence of limestones holding fossils on Lake Manitoba, twelve miles distant in a south-westerly direction, and of limestones holding fossils on Lake St. Martin, eleven miles distant in a south-easterly direction. Also reference might be made to the above-mentioned bore on Vermilion River, where the gypsum was at the base of a bed of Devonian limestone one hundred and thirty feet in thickness. Thus these deposits are practically of about the age of the Onondaga Formation of New York and Western Ontario, in which rocks plaster-quarries have been worked for many years. This Formation also contains the great salt deposits of Ontario, and it is a significant fact, that a short distance to the west of the area under consideration, around the shores of lakes Manitoba and Winnipegosis, many brine springs are known to occur. In the State of Michigan, many of the plaster-quarries are also in rocks of about the same age. In Nova Scotia, the gypsum deposits are of lower Carboniferous age, and in Iowa they are stated to belong to a still higher horizon.

The general hilly and irregular character of the surface underlain by the plaster beds, and the fact that isolated hills of gypsum rise above the surface of the otherwise level plain, make it appear probable that the deposits occur as lenticular masses in the beds of limestone which seem to compose the general floor of this whole area, though in most places the limestone is covered either by a mass of glacial till, or by the alluvial deposits laid down on the bottom of the ancient Lake Agassiz. The gypsum also resembles the limestone in being clearly stratified horizontally or at a very low angle. Besides this, some of the limestone of Northern Manitoba contains a large amount of sulphur scattered throughout its mass in the

form of very minute grains of iron pyrites. The iron pyrites readily oxidises into a sulphate or double sulphate of iron which combining with the carbonate of lime give as products of the double decomposition, sulphate of lime or gypsum, and carbonate or possibly sulphate of iron. In the Cretaceous shales of the Duck and Riding Mountains and of the Plains further west, this process is clearly seen to have gone on. Iron pyrites is constantly present, and the shells of Inocerami, Ammonites, Baculites, &c., furnish an abundant supply of carbonate of lime. This shale is therefore often filled with minute, or sometimes even large crystals of gypsum, and side by side with them are masses of ironstone or impure carbonate of iron, which, after being formed in the above-described way, has collected in rounded or lenticular nodules about a shell, fragment of a crayfish, or other nucleus. In the case of the Paleozoic limestones, however, no trace is found of the carbonate or other salt of iron which would have resulted from the double decomposition, and if it was ever formed in the rock, it has since been dissolved away by water percolating through the strata.

The gypsum may, however, have been formed in a different way. The whole of this country has undoubtedly suffered very considerable erosion since Cretaceous times, the shales and marls of the Duck and Riding Mountains having almost certainly extended much further east than Lake St. Martin. Many of the springs that now flow from these shales are strongly impregnated with sulphuretted hydrogen, which might readily be oxidized into sulphuric acid. This acid acting slowly on the beds of limestone would alter them into sulphate of lime without disturbing the stratification at all.

Of the uses of gypsum it is unnecessary to speak. In the Western States, where the air is dry and atmospheric erosion is very small, it is used as a building stone, being very easily worked, and sufficiently durable and strong for residences and all ordinary buildings.

By roasting, its water of crystallization is driven off and

it is reduced to the fine powder commonly known as Plaster of Paris. By grinding the crude gypsum as it comes from the quarries between ordinary burr-stones, land-plaster is obtained, a substance of which it is difficult to over-estimate the value in a country whose resources are almost entirely agricultural. The soil of Manitoba and the North-West Territories is very fertile now, but a time will come when having raised crop after crop it will need replenishing. The value of this extensive gypsum deposit will then be thoroughly realised. Lying as it does within twelve miles of Lake Manitoba, a navigable stretch of open water extending southward almost to the Manitoba and North-Western Railway, it can readily be brought to all parts of the province. It is also on the line of the projected railway from Winnipeg, between Lakes Winnipeg and Manitoba, to Hudson's Bay, and by this railway would be within one hundred and fifty miles from Winnipeg, and as the intervening country is very level, the cost of carrying it there would not be great.

Notes on Shepherdia Canadensis.

By D. P. Penhallow.

During the past summer I received from a correspondent —Dr. M. S. Wade, of British Columbia—some specimens of plants for identification. Among the number was *Shepherdia Canadensis*, the berries of which are used somewhat extensively as an article of food, and as they possess properties which do not appear to be generally recognized in published accounts of the plant, it seems desirable to make some statements of the facts brought to my notice. Dr. Wade writes as follows :—

" The *Shepherdia Canadensis* is called *Le Bron* and also *Sopolallie*. The latter name is the Chinook word for it, sop meaning *soap*, and olallie *berry*. Thus it is termed the Soap-berry, from its property, when triturated, to form a

mass of stiff foam or lather. The Indian name for it is *Squazsham*. The natives dry it on hay or straw, and thus preserve it for making the soap in the winter months. Several of the white residents, myself included, like the peculiar product from this berry. We preserve it with sugar as other fruits."

On referring to various publications, I find but brief and unsatisfactory statements with reference to the properties and uses above indicated.

Macoun[1] refers to it as known locally as "Soopoolalie," and on the authority of Mr. James Fletcher, states that the Indians make a cooling drink from the berries.

In answer to inquiries, Mr. Fletcher has kindly forwarded a letter from one of his correspondents, Mr. J. D. Tolmie, of Clovendale, B. C., who writes as follows :—

"The Soapoolalie is not used as a drink that I know of. The berries are beaten with a little water in a basin until they froth up like the whites of eggs, and when the basin is quite full, the preparation is eaten with long sticks for spoons. These sticks are shaped something like an oar, are very light and highly polished. When the contents of the basin get low, they are again and again beaten until all the guests are satisfied. I believe the H. B. Co. people called this preparation *La brue* (?), why I know not. When it is sweetened, it resembles in taste and appearance rose or pink cream, and is not unpleasant to take. I have often, in my younger days, partaken of it, and one has the sensation of being quite bloated or puffed out after eating even a small quantity. A strange thing about this dish is that if the smallest particle of cream, grease or fat gets into it, the foam, froth or fluff goes down and will not come up again, leaving only the seeds and a small quantity of reddish water in the basin."

Gray[2] simply refers to the fruit as being yellowish-red and insipid. Bessey[3] speaks of the plant as frequently

[1] Cat. Can. Plants, 421.

[2] Manual, p. 425.

[3] Text Book of Botany, p. 492.

cultivated for its acid fruit. Provancher[1] says the jelly made from its fruit is often preferred to that made from the gooseberry.

("On fabrique avec leurs fruits des gelées que plusieurs préfèrent à celles des groseilles.")

We are indebted to Dr. Wade for a specimen of the jam made from these berries. His directions for the preparation of the soap from it are as follows:—

"Place the jam in a bowl and add an equal quantity of cold water. Take an egg-beater and very *slowly* agitate it for two or three minutes, and then beat more quickly. It will speedily froth up and become quite thick. When so stiff that it will keep its shape pretty well, add a table-spoonful of sugar, and then resume beating with the egg-beater, and continue until the substance is quite thick and firm. At first the preparation may not be liked, but the taste grows on one. Two things must be carefully seen to, to ensure success: first, every article used must be quite free from even a suspicion of grease, and second, the beating must be very slowly done at first."

"The fruit is preserved either by drying in cakes or by boiling, like jam, when the seeds are sometimes removed. I have always seen it beaten up with the hand."

We find that the fresh jam is in appearance, about the color of currant jam, and possesses a somewhat astringent and well-pronounced bitter taste, the latter being rather persistent. Following the directions given above, we found five minutes ample time in which to convert the jam into a cream of the color of strawberries and of about the same texture and firmness as the whipped white of eggs. The most conspicuous feature of the cream is its pronounced bitter taste, which persists for some time. There is, however, a secondary flavor of an agreeable nature and very similar to that of the high bush cranberry. As one becomes accustomed to its use, the bitter taste is rather lost sight of, and the more agreeable flavor becomes more conspicuous.

[1] Flore Canadienne, p. 505.

Nevertheless, we should hardly care to use the jam in large quantity, unless all other material failed.

The dried berries also sent by Dr. Wade, were found to be very sticky and formed a compact mass. They closely resemble dried currants, though much more sticky. The mass contained leaves of the same plant and small fragments of straw; otherwise the material was very clean. To the taste, the berries are sweetish and acid like a currant,—the bitter taste being again most pronounced.

As we have been unable to find an analysis of these berries, we have, through the kind assistance of Dr. Harrington, made determinations of the bitter principle or saponin with the following result:—

Water in air dried berries at 100° C = 23·46 p. c.
Saponin in berries dried at 100° C = 0·74 p. c.

Both the bitter quality and saponification depend upon the saponin, which, though present in rather small quantity, is still ample to give an abundant froth, as copious saponification will occur with only 0.10 p. c.[1]

The *Shepherdia Canadensis* is very widely distributed through Canada from New Brunswick to British Columbia, although it is nowhere locally abundant. Its congener the Buffalo-berry (*Shepherdia argentea*), possesses similar properties, but is much more restricted in its distribution, occurring only in the Northwest, where its centre of distribution is found in the valley of the South Saskatchewan, extending thence along the tributary and adjacent streams.

[1] Wittstein. Org. Constit. of Plants, p. 201.

FORESTRY FOR CANADA.[1]

BY H. G. JOLY DE LOTBINIÈRE.

The forest does not only supply the invaluable commodities of fuel and lumber, it exercises a great influence on the climate, and on agriculture. If science has not yet admitted that the presence of forests increases the rainfall (by condensation of vapour held in the atmosphere, owing to the lower temperature of the forest land, or by other means), it is universally admitted that the forest regulates, throughout the year, the distribution of water in our streams, contributes to retain the moisture favourable to vegetation, retards evaporation and checks the effects of drying winds.

Unfortunately, it is only after the forest is gone, that its value is truly appreciated, as in the South of France, Spain, Italy, Greece, and many other countries, once fertile, now barren and unproductive. The two great extremes, long drought and disastrous inundations, are due to the same cause, viz: the wholesale destruction of the forests, especially on the mountains, the birthplace of the streams. The soil of many a fertile valley is now hidden under a thick bed of sand, gravel and boulders (as we often see in Switzerland) brought down by torrents from the mountain slopes, where the trees which once retained the ground with their roots, have been destroyed. The rain, instead of soaking gradually through the moss, vegetable mould and roots, and feeding, by degrees, the springs and streams, as it did, while the forest lived, rushes down to the valleys below, as it falls, as from the sides of a roof, in irresistible torrents, carrying with it the ground that nothing now retains on the steep mountain side.

It is most interesting to follow the work of re-afforesting carried on, principally in France, on the Landes for nearly a century, and on the barren mountain slopes, and to notice their beneficial results. The efforts of the "Ligue du

[1] Sommerville lecture, delivered March 7th, 1889.

Reboisement de l'Algerie" to repair the harm done in Algeria, by the burning of the forests on the slopes of the Atlas, deserve the warm sympathy of all those who can appreciate perseverance and devotion to the public good.

But the subject before us to-day, is "Forestry for Canada." It is difficult to awaken any interest in the question among us. We are apt to consider Forestry as a superfluity, here, as if our forests were inexhaustible. They would be so (saving accidents by fire) with judicious management and sufficient protection. The aim of Forestry is not, as many believe, to preserve trees for ever, or until they decay and fall. Quite the reverse; it is to select and cut down every tree ripe for the axe, making room for the young growth, and thereby insuring a continued reproduction and a steady revenue. As it is, we are not only spending our revenue, we are drawing largely every year, upon our capital.

The pride of the Canadian forest, the white pine, is getting very scarce; the proportion of first.class wood is decreasing year by year, while the distance from which it is brought is increasing. How many mill owners, who would have scorned sawing spruce logs a few years ago, are only too glad to get them now, and though spruce reproduces itself much more readily than pine, we can foresee the time when it will get very scarce, at the present rate of cutting.

The late James Little, of Montreal, who was the first to sound the alarm, deserves to be gratefully remembered by Canada. When every one treated our pine as if the supply were inexhaustible, he was the first to call attention to its rapid disappearance. His warnings were met, not only with indifference, but with ridicule. Now, the eyes of the most sceptical are opened, and they must admit that he was right; but it is sad to see them turn round now and affirm that it is no use devising means for the protection of our forests, because there is nothing left in them worth protecting. There is still a great deal left worth caring for and improving. It is late, but not too late.

The great American forester, F. B. Hough, in his Report to Congress, draws attention to the fact that: "although

"the system of management of the Canadian forests is crude "in its provisions, and destitute of any policy tending to "secure the growth of new forests, *it has one redeeming* "*feature,* as the title to the land itself remains vested in "the Government, and, after the expiration of the first "temporary leases, under which the native timber is cut, "it will be available for any course of management that "experience may suggest. This last consideration prepares "the way for any system of Forestry that the wants and "resources of the country may, in future, demand, and, "even without a system, the natural growth of a new forest, "where the old one has been cut away, especially where "the spruce timber prevailed, is, in many places, bringing "forward a supply for future use, although much less effec-"tually than under proper care would be obtained."

Mr. Hough was right to assume that the forests of Canada belong to the Crown, as the proportion in private hands is comparatively insignificant. The Government holds them in trust for the people and is answerable for their good management.

It is a good sign to find in the Dominion Statute Book, 47 Vict., cap. 25, sect. 5, proof that the importance of preserving the forests on the Rocky Mountains is well understood. The Governor-General-in-Council is empowered to make provisions "for the preservation of forest trees on the "crests and slopes of the Rocky Mountains, and for the "proper maintenance, throughout the year, of the *volume* "*of water* in the rivers and streams which have their "sources in such mountains."

In the absence of a regular system of Forestry, there are practical means of protecting our public forests which I will now review as briefly as possible.

First, and most important.—A careful *classification* of Public Lands, under two heads: Lands fit for agriculture, which alone ought to be opened to settlement—lands unfit for agriculture, which ought to be carefully closed against settlement and kept in forest. The best timber lands, especially the pineries, are generally totally unfit for agricul-

ture, it is a cruelty to decoy settlers there. How many hard working men have wasted the best part of their lives in trying to get a living out of such poor soil, and are tied down to it, for want of means to move away with their families; the only result of their work being the ruin of a fine forest and their own ruin. The Quebec Legislature had enacted a wise law in 1883, the Timber Reserve Act, which, I regret to see, is on the point of being repealed. As to the relations between the settler and the lumberman, where there is good faith on both sides, those relations ought to be of the most friendly nature.

SECONDLY.—The Government ought not to force, every year, thousands of square miles of timber limits on the market in advance of the legitimate requirements of the trade, and with the unavoidable result of glutting the European market. The Province is interested in the successful carrying on of the timber trade, as it provides the whole of the raw material which keeps the trade going and ought to get returns for the value of that raw material, proportionate to the earnings of the trade. It will not come amiss here, to quote John Stuart Mill's opinion of the status of our timber trade, from his Principles of Political Economy: "The timber trade of Canada is one example of "an employment of capital, partaking so much of the "nature of a lottery, as to make it an accredited opinion "that, taking the adventurers in the aggregate, there is "more money lost by the trade than gained by it, in other "words, that the average rate of profits is less than nothing." Even supposing the timber trade firmer now than when John Stuart Mill wrote, the Government is not justifiable in encouraging over production, as it does, and it would appear wiser, not only for the sake of the forest, but for that of the Exchequer, if the Government kept the limits not actually required for the reasonable wants of the trade, so that the Province might hereafter benefit by the unavoidable rise in the price of those limits.

THIRDLY.—Strict regulations as to the *minimum size* of logs allowed to be cut, and encouragement to convert trees into

saw logs, instead of square timber, which wastes one-third of the tree in the squaring.

FOURTHLY.—Protection against fire which destroys more trees than the axe, precautions in lighting fires in the woods and in clearing lands by fire, for settlement; this last subject is closely connected with the question of the *classification* of lands and the keeping of settlers from lands unfit for agriculture. Fires are more to be apprehended in pineries and among resinous trees, where the soil is very often unfit for agriculture, than among hardwood trees where the quality of the soil is much better as a rule. Our Provincial Legislature is now considering a good measure calling on the lessees of timber limits to contribute one-half of the costs of protecting their limits against fires, the Province paying the other half. It is, I think, the law in Ontario.

FIFTHLY.—Export duty on saw logs, a most important question. Sir John Macdonald was asked, a few weeks ago, by an influential deputation of lumbermen to repeal the export duty on round logs. He reminded them that in 1886 that export duty had actually been increased at their own request, and told them that the Government would consider before all, the good of the country at large.

We are striving to increase the numbers of our people; we deplore the large emigration from Canada to the United States. Shall we encourage that emigration, by sending away the logs which feed our saw-mills, so that they may get sawn by our neighbours? The sawyer will follow the logs, and we shall drive away thousands of industrious men who will follow the raw material in which they find their work. True, we are offered by the United States free entry for our sawn lumber (or rather there is a talk of its being offered) if we repeal our export duty on logs. On the other side, we are threatened with an addition to the present import duty on sawn lumber, equal to the amount of our export duty on logs, if we persist in retaining it.

Very likely that threat will not be carried out; but whatever happens, unless we give up forever all consideration for the welfare of our own country, we must retain our

export duty on logs, thereby protecting our forests and securing work for our own people.

Creation of New Forests.

It is difficult to compress within the narrow limits of one lecture all the branches of Forestry. After considering the preservation of existing forests, we cannot ignore the necessity for creating new ones, on the prairies of the North-West and our old settlements, denuded of trees, in the East.

As for the North-West, what we want, first of all, is *practical experience.* Many theories have been propounded to explain the absence of trees on the prairies, and Mr. A. T. Drummond, of Montreal, a zealous worker in the cause of Forestry, has written some very interesting essays, on that subject.

No use dwelling on the benefits to accrue from the planting of trees on the North-West prairies. Let the Government make a beginning, by starting experimental Forestry stations, nurseries and plantations of trees, under the care of the Mounted Police, at every one of their permanent headquarters. It will be an example to the settlers; the young trees raised from seed, at a nominal cost in the nurseries, can be given to them. The work will not interfere with the duties of the Mounted Police, and it will interest and improve the men, in every way. *Practical experience* will soon indicate what trees to select, where and how to sow and plant.

I would recommend the *Ash-leaved Maple,* (*Acer negundo*) to start with. The rapidity of its growth, its resistance to the drought, the value of its sap for sugar, which has been scientifically demonstrated by Doctor B. J. Harrington, in a series of experiments, the results of which have been communicated by him to the Royal Society of Canada, in a most interesting paper; all these recommend its culture as a starting point. With that tree, plant cotton-wood, poplar, willow, every kind of fast-growing tree, however inferior in quality, so as to start wind screens, behind which slower

growing but more valuable trees can be cultivated, and fields of grain sheltered from the baneful effects of the drying winds.

If, in the absence of any serious attempts at forest tree culture in the North-West, we are still puzzled how to proceed there, here, in the East, we know beforehand that we are bound to succeed, with proper judgment and care. We know that every soil here, whatever its nature, can grow some kind or other of tree, and that, in many instances, the intrinsic value of the tree is quite out of proportion with the value of the soil: pines on sandy soil; sugar maples on rocky hill sides; ash, on cold, wet soil; tamarac and cedar in swamps; white birch on the worst soil and under most unfavourable climate, and, of course, oak, elm, butternut, black birch, &c., &c., in good soil.

It appears logical to choose the most valuable of trees for a new plantation, when the nature of the soil admits of it, though we often see valueless willows and poplars planted on the best soil and even in gardens. I have tried the black walnut, which sells for a dollar a cubic foot, in Quebec—nearly the price of mahogany. Trees raised from the nut have given me nuts after twelve years growth, but, as my experiments do not extend over fourteen years, however satisfactory to myself, I cannot yet assert that the success is complete. Certainly it is very encouraging, and, I hope, will lead others to try the experiment, which is not an expensive one.

It is impossible to enter into the details of tree planting now, but there are two points which ought not to be overlooked: in our climate, experience shows that it is better to plant trees in the Spring, especially if the soil is in the slightest degree wet or even retentive of humidity, and, secondly, it is useless to attempt tree culture *without good fences*, as cattle will destroy all the young trees. In fact, there are thousands of spots where the cultivation of the soil has been given up, which, in a few years, would be covered with a growth of self sown trees, if the cattle were only kept out by fences.

The results of Forestry are so far removed, and, at the same time, of such national importance, as to make it incumbent on the Government to encourage it by every means: experimental stations, especially in the North-West, in charge of the Mounted Police and the Indian Agents and teachers, nurseries of forest trees and gratuitous distribution of the same, rewards in land grants or exemption from taxation, encouraging the observance of Arbor Day, a School of Forestry, or, until that point can be reached, sending some well qualified young men to study Forestry in the French and German schools, and last, but not least, educating the people, beginning with the children.

Teach, in all the schools, the elements of tree culture, joining practice with theory, whenever possible. No better way to develop in the child the qualities necessary to his success as a man. He will learn forethought, in choosing the proper season, the soil, the tree; care and patience, in digging up and transplanting that tree; perseverance in watching over it, watering it, supporting it, pruning it, cultivating the ground round it; unselfishness, in feeling that he works not only for himself, but that others will enjoy the fruits of his labour.

Supplementary Note to "Classification of Cambrian Rocks in Acadia."

By G. F. Matthew.

In the diagram at page 315, showing the relation of the several Cambrian faunas of the Atlantic and of the Pacific slope of America, the word *Ctenopyge* has been printed in error for *Ceratopyge.* Ctenopyge in Europe is an integral part of the Peltura fauna, and we have no reason to suppose that the vertical distribution of these trilobites differs on this side of the Atlantic from that in Europe.

A vertical line intended to divide three faunas of the Atlantic basin from two of the Pacific side of the American

continent, has been omitted, and the brace which takes its place is misleading. The Olenellus-Bathyuriscus fauna should also be connected with No. 2, Middle Cambrian, rather than with No. 1, Lower Cambrian.

Other changes that should be made in the article are the following:—

Page 310, line 24, omit *System*.

In the table on page 313, as well as in the text on the same page, for *Agnostus intercinctus* read *Agnostus interstrictus*.

Page 314, line 8, after list, insert (*Bathyuriscus* and *Asaphiscus*.

Page 314, line 24, after great, insert vertical.

In the first article of this series (see Vol. III., No. 1, this journal), certain worm-tracks and casts are referred to as being plentiful in the Basal or Etcheminian series. But far more abundant and generally distributed than these are the remains of sponges. The gleaming reflections from their skeletons are common on the surfaces of the finer shales, and their spiculæ are very generally distributed in coarse deposits as well as fine.

Sponges are found in the first beds above the lowest conglomerate, a horizon which is about sixty feet from the base of the terrein, and about fifteen hundred feet below the Paradoxides beds. At various horizons in the Basal series have been found different kinds of sponges: some of the basket-sponge group; others of the ordinary silicious kinds. The latter present several varieties of form, some are tubular, others branching with a solid axis, and others again are amorphous with numerous orifices (cloaca) of irregular form.

Even the sandstones are replete with the debris of sponges, both silicious granules and fragments of the sponge cuticle and of spiculæ are plentiful among the sand grains, of which these beds are composed. So we may see that sponges have played an important part in the building up of sedimentary deposits at the very dawn of Palæozoic Time.

On Archæocyathus, Billings, and on other Genera allied thereto, or associated therewith from the Cambrian Strata of North America, Spain, Sardinia and Scotland.

By Dr G. J. Hinde, F.G.S.

(*Abstract.*)

A revision of the type specimens of the three species included by Mr. Billings in the genus *Archæocyathus* shows that each of the species represents a distinct genus. *Archæocyathus profundus*, having been selected by Mr. Billings in 1865 as the typical species, was retained as such, and the characters of the genus, as shown in this species were defined; *Arch. atlanticus*, Bill., was made the type of a new genus, *Spirocyathus;* and the third species, *Arch. minganensis*, which proves to be a siliceous sponge, was included in a new genus, *Archæoscyphia.*

Including the genera allied to *Archæocyathus*, described by Meek and Bornemann, the following constitute the family Archæocyathinæ, proposed by this last-named author; *Archæocyathus*, Bill.; *Ethmophyllum*, Meek; *Coscinocyathus*, Born.; *Anthomorpha*, Born.; *Protopharetra*, Born.; and *Spirocyathus*, g.n.

The genera of this family are characterized for the most part by turbinate or subcylindrical forms with stout walls enclosing an interior tubular or cup-shaded cavity. Their skeletons are carbonate of lime in a minutely granular condition. The walls in the first four of the above-named genera consist of an outer and inner lamina connected by vertical and radial septa; dissepiments are generally present between the septa; save in the genus *Anthomorpha*, the outer lamina of the wall is regularly and minutely perforate, and the inner lamina and septa are likewise cribriform; *Ethmophyllum* is particularly distinguished by oblique canals connecting the interspaces of the wall with the central cavity, *Coscinocyathus* by transverse, perforate tabulæ, and *Anthomorpha* by the apparently imperforate character of the surface-laminæ and septa. *Protopharetra* and *Spirocyathus*

are either non-septate, or very obscurely septate; their skeleton consists of anastomosing laminæ and fibres; in the latter genus the laminæ are remarkably thickened by successive secondary deposits of calcareous material.

The Archæocyathinæ are regarded as a special family of the *Zoantharia sclerodermata*, in some features allied to the group of perforate corals. The family is restricted, so far as is known at present, to the lowest fossiliferous zone of the Cambrian strata, that characterized by the genus *Olenellus*, Hall, and it occurs at Anse-au-loup, Labrador; Troy, New York State; Nevada; in the Sierra Morena, Spain, and in the south-west of the Island of Sardinia.

The genus *Archæoscyphia*, based on *Archæocyathus minganensis*, Bill., is shown to be a lithistid sponge, and *Nipterella*, g.n., based on *Calathium* (?) *paradoxicum*, Bill., belongs likewise to the same group of sponges. The genera *Calathium*, Bill., and *Trichospongia*, Bill., are also undoubted siliceous sponges. These various sponges, which were either included in *Archæocyathus* by Mr. Billings, or regarded as allied thereto, have no relation whatever to the genus, or to any member of the family in which it is included. They come from a higher geological horizon, the Calciferous formation of the Canadian geologists, which is probably the summit of the Cambrian. They occur in the Mingan Islands and in Newfoundland. *Archæoscyphia* and *Calathium* are present in the Durness limestones.—(*Proc. Geol. Soc., Lond., Dec. 9th,* 1888.)

Proceedings of the Natural History Society, Montreal.

The first monthly meeting of the Session was held on the evening of October 29th, 1888, at 20 o'clock

Attendance: 21 members.

On motion of Prof. Penhallow, seconded by J. S. Brown, Prof. Mills took the Chair in the absence of the President.

The Minutes of the April monthly meeting were read

and approved, also those of the Council meetings held since that date.

Moved by J. S. Brown, seconded by S. Finley, that Mr. Brown's motion, *re* collection of fees as recommended by Council, be adopted. Carried.

The following donations were reported:—"Milk Snake," from Mr. James Ferrier; and the "Geological History of Plants," from Sir Wm. Dawson.

On motion of E. T. CHAMBERS, seconded by Prof. Penhallow, the thanks of the Society were tendered to the donors.

Members proposed:—Edgar Judge, Prof. H. T. Bovey, Chas. Patton, E. L. Bond, Dr. Stirling, as ordinary members; and Master H. J. M. Smith and Miss Annie Louise Smith as associate members.

On motion of Prof. Penhallow, seconded by R. W. McLachlan, the Rules were suspended and the above named ballotted for and elected.

A letter of resignation, from Mr. F. L. Wanklyn, was read and the resignation accepted.

Prof. Penhallow read a Paper entitled "Notes on Ringed Trees," by Prof. W. L. Goodwin, of Kingston, to which he added some very interesting and instructive remarks, which he also explained by diagrams.

The Paper was fully discussed by Prof. Mills, Dr. Wanless and other members.

In the absence of Mr. F. Adams, Prof. Penhallow read extracts from his Paper "On some Canadian Rocks containing Scapolite, and a few Notes on some Rocks associated with the Apatite deposits."

The thanks of the Society were tendered to Prof. Penhallow and the contributors of the above Papers.

(Signed,) J. W. DAWSON, Pres.

The second monthly meeting was held on the evening of November 26th, 1888, at 20 o'clock.

Present:—Sir Wm. Dawson (in the Chair), Prof. Pen-

hallow, J. S. Shearer, J. A. U. Beaudry, Rev. J. G. Baylis, Dr. Harrington, R. W. McLachlan, Prof. Mills, J. H. R. Molson, P. S. Ross, and a number of visitors.

In the absence of the Secretary, Mr. J. S. Brown acted.

The Minutes of the last meeting were read and confirmed. The Minutes of last Council meeting were also read.

It was moved by Mr. Shearer, seconded by Mr. Beaudry, that a Conversazione be held in January, and that a special meeting of Council be called for Monday, 3rd December, for the purpose of organizing a Committee to carry out the same.

Sir Wm. Dawson presented for the Library a copy of his pamphlet, "Notes on Specimens of Eozoon Canadense," and Mr. Shearer presented a very fine specimen of Star Fish, *Astrophyton Agassizii*, for the Museum.

A vote of thanks was tendered to the donors.

The following names were proposed for membership:—Dr. Lovejoy, Alexander Henderson, Horace T. Martin.

On motion of Mr. Beaudry, seconded by Prof. Penhallow, the by-laws and ballot were suspended, and the above named gentlemen were elected by acclamation.

Rev. Prof. Kavanagh then read a very interesting Paper on "Modern Concretions from Boucherville," &c., illustrating his subject by specimens gathered from localities referred to.

The subject provoked considerable discussion by members present. A warm vote of thanks was tendered the author, with the request that he would again favour the Society on some future occasion.

Sir Wm. Dawson then addressed the Society, first upon "Pleistocene Fossils from River Beaudette," and afterwards upon "Recent and Fossil Species of Mya." The speaker was listened to with marked interest, and a general discussion followed these subjects.

At the close of his remarks, Sir William presented to the Museum, on behalf of Messrs. H. G. Stanton and A. W. McGoun, the specimens of *Balanus Hameri*, with which he had illustrated the first of his subjects, remarking that the

thanks of the Society were due to these gentlemen for having brought to its notice an extremely interesting subject.

A formal and cordial vote of thanks was passed to the donors.

Mr. J. S. Shearer occupied the Chair while the President addressed the meeting.

Meeting adjourned.

(Signed,) J. W. DAWSON, Pres.

MONTREAL, 17th Dec., 1888.

The third monthly meeting was held on the evening of December 17th, 1888, at 20 o'clock.

Present:—Sir Wm. Dawson in the chair.

Minutes of last meeting were read and approved. The Minutes of the Council meeting were also read.

Mr. J. S. Brown reported the proceedings of the Conversazione Committee.

The Honorary Corresponding Secretary reported new exchanges received.

Mr. E. T. Chambers read his Paper, "Notes on Lake St. John District," giving a very interesting account of this region, and also exhibited specimens collected by him. He referred particularly to the natural history and geological formations of the country.

The President made some remarks on a fine specimen collected by Mr. Chambers at Lake St. John, which seemed to be a new species of Cryptozoon.

A cordial vote of thanks was tendered to Mr. Chambers for his interesting Paper.

Dr. Harrington was requested to ask Mr. Low to read a Paper before the Society on his trip to Lake Mistassini.

The President also made some remarks on a Paper on "The Classification of the Cambrian Rocks in Acadia," by G. F. Matthew, referring to new discoveries in the Lower

Cambrian of New Brunswick. The Paper was taken as read, as it will appear in the next number of the *Record of Science.*

In the absence of Mr. H. M. Ami, his paper on the "Flora of Montebello" was read by Prof. Penhallow. It referred to the collection made there by him on the "Field Day" of the Society in June last. One hundred and seventy-nine species in all were found in the vicinity, of which 163 were obtained in the Manor Grounds. The Paper called forth an interesting discussion on the laws of distribution of plants, and the relation of soil composition and geological formation to distribution and disease.

As the above Paper is to be published in the *Record of Science,* the Chairman of the Editing Committee was requested to send copies to Mr. Ami and the Hon. Mr. Papineau. A hearty vote of thanks was tendered to Mr. Ami and Mr. Matthew.

The fourth monthly meeting of the Society was held on the evening of January 28th, at 20 o'clock, Sir Wm. Dawson in the Chair.

The Minutes of last meeting were read and approved. The Minutes of Council meeting of 21st inst. were also read.

Dr. Harrington reported that all arrangements for the Sommerville Course of Lectures had been made, and that the first would be given on the 21st of February.

The Hon. Curator announced the following donations:— *Tamais striata,* Albino variety, from W. H. Rintoul. Specimens of Lepidoptera, Coleoptera. &c., from P. M. Dawson.

The following gentlemen were proposed: James Coristine, Wm. Euard, E. A. Small, J. H. Jones, E. F. Carter as ordinary members, and E. H. Carter as associate member, by J. S. Brown, seconded by J. S. Shearer.

Mr. Shearer proposed, seconded by Mr. Brown, the follow-

ing as ordinary members:—J. C. Holden, S. Wentworth Hill, Wm. Minto, W. A. Stephenson, C. S. J. Phillips, Wm. Notman, Geo. Phelps.

Moved by Mr. Brown, seconded by P. S. Ross, that the rules be suspended and the above named be balloted for. Carried.

Mr. J. S. Brown reported favourably on the progress of the Conversazione Committee, stating that an invitation had been sent to the Governor-General and Lady Stanley.

The Hon. Librarian reported the donation of a Paper on "The Eozoic and Palæozoic Rocks of the Atlantic Coast of Canada," by Sir Wm. Dawson.

The thanks of the Society were tendered to the above donor.

Prof. T. Wesley Mills gave a very interesting address on "The Influence of the Nervous System on Cell Life."

Prof. Penhallow read "Some Notes on the Fruit of the *Sheperdia Canadensis*, which is largely used in the North-West as an Article of Food."

The President read a letter from Mr. E. Cuthbert, of Berthier, describing a remarkable land-slip which occurred in December on the River Bayonne.

A hearty vote of thanks was tendered the above gentlemen.

Mr. P. S. Ross showed some specimens of Limonite collected at Hopewell, N.S.

(Signed,) J. H. Joseph.

(Signed,) A. H. Holden,
Rec.-Sec.

The fifth monthly meeting was held on the evening of February 25th, 1889, at 20 o'clock.

In the absence of the President, Mr. J. H. Joseph was elected Chairman.

The Minutes of the last monthly meeting were read and approved, also the Minutes of Council meeting of 18th Feb.

The Hon. Curator reported the following donations: From Mr. Romeo Stephens, stone-gouges, &c., and from Mr. Van Horne a mounted Cariboo.

On motion of Prof. Penhallow, seconded by Dr. Harrington, the thanks of the Society were tendered these gentlemen.

The following were proposed for membership :—Leslie D. Skelton, T. E. Vasey, Percy M. Dawson, E. D. Lacey, W. A. Dyer, James Morgan, Jr., Hugh Paton, George Knowlton, Jas. Y. Gilmour, H. M. Belcher.

On motion of Mr. Brown, seconded by Mr. Sumner, the rules were suspended and the above gentlemen were duly elected.

Dr. Harrington gave a very interesting address on Coals from the North-West, illustrating his remarks by samples from a number of mines.

A vote of thanks was moved by Mr. J. S. Brown, seconded by Prof. Mills. Carried.

In the absence of Sir Wm. Dawson, Prof. Penhallow read a note by the President (Sir Wm. Dawson), on a new Devonian plant, *Dictyocordaites Lacoi*, which had been discovered by Mr. R. D. Lacoe, of Pittston, Pennsylvania, and appeared to be intermediate in characters between the ancient Gymnospermous genera known as Cordaites and Noeggerathia. A photograph of the plant was exhibited. It will be described more at length in a future number.

Prof. Penhallow also read "Supplementary Notes to Paper on Cambrian," by Mr. G. F. Matthew.

On motion of Mr. Sumner, seconded by Mr. Chambers, a vote of thanks was tendered to Sir Wm. Dawson and Mr. Matthew for these papers, and to Prof. Penhallow for his interesting remarks on the same.

Moved by Prof. T. Wesley Mills, seconded by Prof. D. P. Penhallow, that a special vote of thanks of the Society be tendered to Mr. Matthew for the above paper and for former contributions.

Meeting adjourned.

(Signed,) J. W. Dawson, Pres.

The sixth monthly meeting of the Society was held on the evening of March 25th, 1889, at 20 o'clock. Sir William Dawson in the chair.

The minutes of last meeting, as well as the minutes of Council meeting held on 18th March, were read and approved.

Mr. J. S. Brown reported that owing to the absence of the gentleman who had made the offer to subscribe $1000 on behalf of a Zoological Garden, he was unable to give any further information on the subject.

The Treasurer of the Conversazione Committee made an informal report that all accounts had been paid, leaving a cash balance of $100.79. Report adopted.

Moved by J. S. Brown, seconded by J. S. Shearer, that the thanks of the Society be tendered to the different contributors of exhibits to the Conversazione. Carried.

Mr. John Murphy was proposed for membership, and the rules being suspended, he was elected by acclamation.

Prof. T. Wesley Mills gave a very interesting "exhibition and explanation of specimens, bearing on reproduction in birds."

Dr. Harrington, in the absence of Mr. J. B. Tyrrell, and Mr. Robert Chalmers, read the following papers, "Gypsum deposits of Northern Manitoba" by the former, and "The Glaciation of Eastern Canada" by the latter. The latter paper went to show that the views laid down by Sir Wm. Dawson thirty years ago, had received ample confirmation by new discoveries.

The President made some very interesting remarks on the above papers, and the thanks of the Society were tendered to the contributors.

Mr. F. B. Caulfield announced that his paper for next meeting would be "On some birds observed at Montreal."

MISCELLANEOUS.

SPERRYLITE, A NEW CANADIAN MINERAL.—This remarkable mineral has recently been described by Professors Wells and Penfield, of the Sheffield Scientific School, New Haven, who received it from Mr. Francis L. Sperry, of Sudbury, Ontario, Chemist to the Canadian Copper Company. The mineral occurs at the Vermilion mine, Algoma, twenty-two miles west of Sudbury, and is associated with chalcopyrite, pyrrhotine, minute grains of cassiterite, &c. It consists of minute, brilliant grains and crystals from $\frac{1}{500}$ to $\frac{1}{30}$ inch in diameter, of nearly tin-white colour, and specific gravity 10.602. The following analysis by Prof. Wells show that it is an Arsenide of Platinum and that its composition may be represented by the formula $PtAs_2$:—

	I.	II.	Mean.
As..................	40.91	41.05	40.98
Sb..................	0.42	0.59	0.50
Pt..................	52.53	52.60	52.57
Rh..................	0.75	0.68	0.72
Pd..................	trace	trace	trace
Fe..................	0.08	0.07	0.07
SnO_2..................	4.69	4.54	4.62
	99.38	99.53	99.46

The mineral decrepitates slightly when heated. In the closed tube it remains unchanged at the fusing point of glass. In the open tube it gives very readily a sublimate of arsenic trioxide and does not fuse if slowly roasted, but if rapidly heated it melts very easily after losing a part of the arsenic. According to the investigations of Professor Penfield, the crystals of Sperrylite show the combination of cube, octahedron, pyritohedron and very rarely dodecahedron. The hardness of the mineral is between 6 and 7.

The above details are taken from the papers of Professors Wells and Penfield in the American Journal of Science for January, 1889.

B. J. H.

ABSTRACT FOR THE M

Meteorological Observations, McGill College Observatory, Montreal, Cana

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pressure of vapour.
1	28.83	31.0	26.7	4.3	29.8358	29.885	29.771	.114	.1302
2	24.78	30.7	18.4	12.3	29.9133	30.046	29.791	.255	.1148
3	17.98	24.1	15.0	9.1	29.9955	30.063	29.937	.126	.0933
4	26.20	30.7	18.4	12.3	30.1632	30.262	30.059	.203	.1245
5	27.13	30.0(?)	25.0(?)	5.0	30.3035	30.372	30.211	.161	.1275
SUNDAY........ 6	.....	30.1	21.7	8.4	....	......	......	....	....
7	31.32	33.1	29.7	3.4	29.5900	29.684	29.534	.150	.1640
8	31.62	34.0	29.7	4.3	29.8435	29.946	29.659	.287	.1605
9	32.68	39.5	28.7	10.8	29.4490	29.810	29.064	.746	.1702
10	29.73	34.5	22.0	12.5	29.3807	29.790	29.115	.675	.1488
11	23.98	27.0	20.8	6.2	29.9467	30.038	29.853	.185	.1057
12	19.17	23.3	16.0	7.3	30.2653	30.364	30.113	.251	.0730
SUNDAY........13	.....	19.0	10.8	8.2	....	......	......	....	....
14	11.92	16.7	7.0	9.7	30.4423	30.481	30.408	.073	.0625
15	17.18	22.2	9.6	12.6	30.3902	30.447	30.322	.125	.0775
16	25.80	37.0	18.0	19.0	30.0513	30.293	29.678	.615	.1182
17	38.68	44.0	34.6	9.4	29.4798	29.627	29.347	.280	.1935
18	29.53	35.2	20.3	14.9	29.8403	30.040	29.688	.352	.1212
19	3.13	21.0	-2.4	23.4	30.5333	30.685	30.253	.432	.0337
SUNDAY........20	....	12.0	-3.0	15.0	......	......	......	...	....
21	13.45	17.9	9.4	8.5	29.6650	29.836	29.493	.343	.0718
22	9.98	15.1	4.0	11.1	30.2880	30.471	30.024	.447	.0503
23	8.83	15.5	4.8	10.7	30.4482	30.513	30.353	.160	.0545
24	26.85	36.3	7.6	28.7	30.1128	30.268	29.991	.277	.1273
25	31.05	37.0	25.8	11.2	30.0572	30.130	29.988	.142	.1302
26	23.35	32.1	14.8	17.3	30.0185	30.046	29.995	.051	.1042
SUNDAY........27	...	16.0	11.1	4.9	....	......	....	....	....
28	16.72	20.7	12.7	8.0	29.2380	29.326	29.120	.206	.0793
29	11.17	17.1	6.0	11.1	29.5748	29.858	29.347	.511	.0567
30	0.13	6.5	-4.3	10.8	30.1172	30.252	29.943	.309	.0275
31	11.97	33.3	-6.5	39.8	29.8685	30.171	29.613	.558	.0805
............Means	21.23	26.54	14.59	11.94	29.9560	......	......	.298	.1038
15 yrs. means for & including this mo.	11.59	20.20	3.34	16.85	30.0610	......	......	.339	.0717

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
Miles............	1839	1801	239	527	1219	4913	2941	318	
Duration in hrs..	106	104	14	40	62	207	154	23	34
Mean velocity...	17.3	17.3	17.1	13.2	19.7	23.7	19.1	13.8	

Greatest mileage in one hour was 52 on the 10th
Greatest velocity in gusts 60 miles per hour on the 10th.

Resultant mileage, 5063
Resultant direction, S 70° W.
Total mileage, 13,797.

ONTH OF JANUARY, 1889.

a, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

‡ Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
82.0	24.2	S.W.	18.6	10.0	10	10	00	....	0.2	0.02	1
83.7	20.7	S.	10.2	10.0	10	10	00	....	0.9	0.09	2
95.0	16.7	S.	9 7	7.0	10	0	21	0.02	Inapp.	0 02	3
87.5	23.0	W.	8.3	10.0	10	10	00	...	....	....	4
86.3	23.5	N.	20.7	7.3	10	1	12	....	....	....	5
....	....	N.	14.3	....	..	..	00	0.15	....	0.15	6 ....SUNDAY
93.5	29.7	N.	13.1	10.0	10	10	00	0 46	3.3	0.78	7
91.5	29.0	S.W.	17.9	6.8	10	0	53	....	0 3	0.03	8
91.2	30.7	S.E.	16 7	10.0	10	2	00	0.99	Inapp.	0.99	9
88.5	27.0	S.W.	37.7	8.0	10	0	00	....	1.6	0.16	10
82.0	19.3	W.	23 2	7.8	10	0	00	....	0.2	0.02	11
70.3	11.2	W.	21.1	2.2	10	0	66	....	....	....	12
....	....	W.	4.8	....	.	..	51	....	....	...	13 ....SUNDAY
84.2	8.0	S.W.	8.3	2.7	10	0	50	....	Inapp.	0.00	14
81.2	12.3	S.W.	20.6	4.7	10	0	88	....	.. .	....	15
82.8	21.3	S.E.	13.5	9.5	10	7	00	....	....	0.01	16
80.7	33.0	S.W.	32.7	8.7	10	2	51	0.01	....	0.22	17
73.7	22.2	S.W.	24 6	10.0	10	10	13	0.22	Inapp.	0.00	18
66.3	-5.8	W.	17.8	2.0	10	0	95	..	0 2	0.02	19
...	....	N.E.	15.0	...	.		54	....	2.0	0.13	20 ....SUNDAY
89.7	10.8	N.E.	19.0	10.0	10	10	00	....	18.3	0.92	21
73.5	3.2	W.	26 0	1.2	7	0	100	....	Inapp.	0.00	22
84.3	4.8	S.	14.9	1.5	6	0	67	....	....	..	23
85.2	22.7	S.	22.7	7.8	10	0	00	0 03	0.2	0.05	24
74.8	24.0	S W	26 0	4.2	9	0	60	. ..	....	....	25
82.3	18.8	N.W.	23 3	8.3	10	0	00	....	....	...	26
....	....	N.E.	27.1	....	..	..	00	...	4.1	0.41	27 ....SUNDAY
86.0	13.2	N.W.	17.3	10.0	10	10	00	....	5.0	0.36	28
77.2	5.3	W.	21.8	1.8	10	0	67	....	1.8	0.13	29
64.2	-10.0	N.	10.6	0.3	1	0	96	....	...	....	30
90.2	9.3	N.E.	17 2	10.0	10	10	00	....	2.4	0.16	31
82.5	16.6	......	18.5	6.73	..		30.5	1.88	40.5	4.67	Sums ....
80.7	....	....	....	6.34	..	..	¶33.5	0.79	30.3	3 64	15 years means for and including this month

•Barometer readings reduced to sea-level and temperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 44.0 on the 17th; the greatest cold—6.5 on the 31st, giving a range of temperature of 40.5 degrees. Warmest day was the 17th. Coldest day was the 30th. Highest barometer reading was 30.708 on the 20th; lowest barometer was 29.064 on the 9th, giving a range of 1.644 inches. Maximum relative humidity was 100 on the 3rd and 31st. Minimum relative humidity was 48 on the 30th.

The mean temperature is the highest for January in 15 years, except that for 1880, which was 22.45 degrees. The average minimum is 5 degrees in excess of the highest, and the average range of temperature is the least for January in 15 years.

Rain fell on 7 days.

Snow fell on 19 days.

Rain or snow fell on 22 days.

Hoar frost on two days.

Lunar halo on the 15th and 16th.

Fog on six days.

Solar halo on the 27th.

ABSTRACT FOR THE M(

Meteorological Observations, McGill College Observatory, Montreal, C

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pres-sure of vapour
1	9.35	30.5	-1.1	31 6	29.8675	29.995	29.618	.377	.0598
2	6.55	16.9	-4.6	21.5	29.7192	29.964	29.561	.403	.0498
SUNDAY. 3	......	11.5	-10.4	21.9	....	......	.....	....	....
4	-9.33	0.4	22.6	23.0	29 9747	30.057	29.877	.180	.0250
5	13.40	22 1	0.4	21.7	29 5753	29.768	29.439	.329	.0757
6	-0.12	23.0	-8 0	31 0	29.5065	29.539	29.488	.051	.0418
7	-0.78	4.4	-7 9	12.3	29.7347	29.963	29 570	.393	.0327
8	11.55	19.1	2 0	17.1	29.9952	30.037	29.948	.089	.0642
9	16 03	19.9	8.4	11.5	29.9437	29.982	29.893	.089	.0822
SUNDAY.. 10	.....	17.8	10.9	6.9	....	......	.....	....	....
11	21.65	26.5	13.0	13.5	29.8540	29.993	29.719	.274	.0957
12	18.87	25.5	9 0	16.5	29.6560	29.683	29.613	.070	.0822
13	4.53	10.0	2 0	8 0	29 5505	29.601	29.507	.094	.0450
14	9.03	16 6	2.0	14 6	29 8760	30.117	29.666	.451	.0497
15	11.45	17.3	4 7	12.6	30.3523	30 424	30.227	.197	.0550
16	15.38	33.6	2.2	31.4	30.1633	30 422	29.810	.612	.0817
SUNDAY........17	.....	39.5	32.7	6.8	....	......	......	...	....
18	23.77	33 7	20.7	13 0	29.6227	29.903	29.222	.683	.1070
19	15.40	28.0	11.6	16.4	29.6877	30.033	29 261	.772	.0715
20	10.23	16.5(?)	3 5	13.0	30.3162	30.426	30.172	.254	.0517
21	15.63	23.0	7.0	16.0	30.4488	30.556	30.229	.327	.0643
22	15.75	34.0	-7.4	41.4	30.0848	30.329	29.903	.426	.0792
23	-10.73	-6.8	-16 9	10 1	30.4585	30.614	30.399	.215	.0202
SUNDAY.... ...24	. ...	6.6	-13.0	19 6	......	......	......	....	..
25	6.57	11.0	0 8	10.2	30.7022	30.807	30.605	.202	.0385
26	5.60	13.1	-7.0	20 1	30.7842	30.885	30.663	.222	.0422
27	16 73	24.1	5 9	18 2	30.5728	30 636	30.525	.111	.0882
28	27.68	33.7	23.3	10 4	30.4378	30.581	30.525	056	.1283
....Means	10.59	19.70	2.19	17.51	30.0410	......	.....	.287	.063
15 yrs. means for & including this mo.	15.24	23.79	6.62	17.17	30.0430	......	......	.318	.080

ANALYSIS OF WIND RECORD.

Direction.......	N.	N.E.	E.	S.E.	S.	S.W.	W.	N. W.	Calm.
Miles..	360	1046	200	725	975	4679	3551	1190	
Duration in hrs..	40	71	24	53	63	216	158	43	4
Mean velocity...	9.0	14 7	8.3	13.7	15.5	21.7	22.5	27.7	

Greatest mileage in one hour was 56 on the 6th.

Greatest velocity in gusts 56 miles per hour on the 6th.

Resultant mileage, 6,875.

Resultant direction, S 65° W.

Total mileage, 12,726.

*Barometer readings reduced to sea-level temperature of 32° Fahr.

NTH OF FEBRUARY, 1889.

ada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

‡ Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
79.2	4.0	W.	32.5	4.5	10	0	82	....	....	....	1
82.5	2.2	N.W.	19.8	5 5	10	0	33	....	0.4	0.02	2
....	....	N.	10.8	....	..	..	63	....	0.1	0.01	3 ....SUNDAY
89.2	-12.0	..	10.7	8.2	10	4	27	....	....	....	4
89.7	10.7	N.E.	17.7	10.0	10	10	00	....	11.2	1.06	5
86.2	-3.7	S.W.	45 1	9.7	10	8	00	....	4 8	0.48	6
79.0	-6.5	W.	33 3	6.7	10	0	00	....	1.3	0.13	7
83.5	6.7	S.W.	14.0	6.8	10	0	19	....	1.2	0.12	8
91.0	14.0	N.	7.7	10.0	10	10	00	....	0.6	0.05	9
....	....	S.W.	10.3	...	..		86	....	0.2	0.02	10 ....SUNDAY
81.2	16.7	S.E.	14.0	8.8	10	3	51	....	0.1	0.01	11
76.8	13.0	S.W.	13.6	8.5	10	1	28	....	5.0	0.40	12
84.5	0.8	S.W.	34.5	9.2	10	5	00	....	1.6	0.16	13
75.3	2.7	W.	30.2	8.0	10	0	45	....	....	....	14
75.7	4.8	S.W.	13.5	0.0	0	0	100	....	....	...	15
83.5	11.3	S.E.	14.8	5.3	10	0	53	0.12	....	0.12	16
...	....	S.W.	22.1 ?	....	.	..	00	0.18	....	0.18	17 ....SUNDAY
83.8	19.5	N.E.	20.1	10.0	10	10	00	....	3.3	0.33	18
81.3	10.8	W.	30.9	6 7	10	1	55	....	0.6	0.06	19
74.0	3.5	W.	19.5	0 5	1	0	79	....	Inapp.	0.00	20
71.5	8.3	S W.	19.1	4.8	10	0	75	....	....	....	21
76.3	9.7	S.W.	24 9	8.7	10	2	00	....	1.4	0.14	22
78.5	-16.0	W.	21.9	1.7	9	0	93	....	....	...	23
...	....	S.W.	17.1	...	..	..	98	....	.. .	....	24 ....SUNDAY
67.2	-2.8	S.W.	11.7	2.7	10	0	87	....	....	....	25
75.0	-1.0	E.	8.2	4.8	10	0	83	....	....	....	26
91.0	14.5	E.	7.7	10.0	10	10	00	....	0.4	0.04	27
85.3	23.7	.....	4.5	3 8	10	0	65	....	....	...	28
80.9	5.62	......	....	6.45	.		43.6	0.30	32.2	3 33	Sums ....
78.4	....	....	....	5.81	..	..	¶41.3	0.76	22.3	2.98	15 years means for and including this month

§ Observed.
† Pressure of vapour in inches of mercury.
‡ Humidity relative, saturation being 100.
¶ Eight years only.

The greatest heat was 89.5 on the 17th; the greatest cold was 22.6 below zero on the 4th, giving a range of temperature of 62.1 degrees. Warmest day was the 17th. Coldest day was the 23rd. Highest barometer reading was 30.885 on the 26th; lowest barometer was 29.222 on the 18th, giving a range of 1.663 inches. Maximum relative humidity was 100 on the two days. Minimum relative humidity was 51 on the 3rd.

Rain fell on 2 days.
Snow fell on 16 days.

Rain or snow fell on 18 days.
Auroras were observed on two nights.
Hoar frost on two days.
Lunar halo on two nights.
Lunar corona on one night.
Fog on four days.
Solar halo on one day.
Small portion of a contact arc. was visible on the 21st.

ABSTRACT FOR THE M

Meteorological Observations, McGill College Observatory, Montreal, C

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pressure of vapour
1	28.75	34.0	22.5	11.5	30.4200	30.503	30.315	.188	.1358
2	28.32	34.5	16.9	17.6	30.2053	30.295	30.122	.173	.1342
SUNDAY. 3	......	39.6	26.9	12.7	....	......	......	....	....
4	32.10	38.9	21.3	17.6	29.8930	30.000	29.779	.221	.1418
5	35.45	38.9	31.7	7.2	29.6623	29.749	29.540	.209	.1623
6	34.93	38.5	32.7	5.8	29.2978	29.451	29.107	.344	.1800
7	30.90	35.9	25.0	10.9	29.0348	29.122	28.982	.140	.1667
8	22.17	25.8	19.9	5.9	29.2843	29.327	29.220	.107	.1052
9	20.78	22.8	17.9	4.9	29.4317	29.578	29.291	.287	.0953
SUNDAY........10	.....	25.0	18.3	6.7	......	......	......	....	....
11	21.93	27.0	16.8	10.2	29.9402	29.960	29.907	.053	.0803
12	26.80	32.9	17.9	15.0	29.9125	29.959	29.874	.085	.1227
13	31.58	41.3	22.8	18.5	29.8095	30.023	29.612	.411	.1230
14	16.92	24.5	11.5	13.0	30.3260	30.383	30.200	.183	.0552
15	25.70	32.3	17.8	14.5	30.1990	30.295	30.121	.174	.1035
16	30.43	39.0	20.8	18.2	30.0972	30.137	30.066	.071	.1245
SUNDAY........17	.....	37.2	27.6	9.6	....	......	......	....	....
18	32.45	35.6	30.7	4.9	29.9307	29.957	29.908	.049	.1592
19	33.58	37.3	29.8	7.5	29.9093	29.946	29.875	.071	.1518
20	34.27	39.3	30.4	8.9	30.0033	30.039	29.962	.077	.1557
21	31.43	37.4	25.8	11.6	30.0748	30.146	30.032	.114	.1102
22	35.40	43.9	25.8	18.1	30.1947	30.258	30.128	.130	.1107
23	38.25	42.6	32.8	9.8	29.9353	30.070	29.773	.297	.1518
SUNDAY.. 24	.....	39.0	29.7	9.3	......	......	......	....	....
25	22.12	31.1	15.9	15.2	29.8647	29.997	29.735	.262	.0703
26	18.80	25.9	7.8	18.1	30.0223	30.074	29.964	.110	.0687
27	33.53	40.0	20.8	19.2	29.8005	29.961	29.682	.279	.1472
28	32.62	39.2	29.0	10.2	29.7447	29.840	29.696	.144	.1453
29	28.78	36.2	19.7	16.5	29.8383	29.999	29.742	.257	.1207
30	18.13	23.0	9.7	13.3	30.2697	30.345	30.149	.196	.0615
SUNDAY 31	......	32.3	15.9	16.4	....	......	......	....	....
....Means.	28.70	34.55	22.32	12.22	29.8885	......	......	.178	.1224
15 yrs. means for & including this mo.	23.69	31.06	16.00	15.06	29.9573	......	......	.266	.1062

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
Miles..	750	3007	138	256	702	3991	3408	658	
Duration in hrs..	66	165	22	30	56	176	140	52	37
Mean velocity...	11.4	18.2	6.3	8.5	12.5	22.7	24.3	12.7	

Greatest mileage in one hour was 45 on the 8th.

Greatest velocity in gusts 52 miles per hour on the 8th.

Resultant mileage, 4,265.

Resultant direction, S 85° W.

Total mileage, 12,910.

)NTH OF MARCH, 1889.

da, **Height** above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

Mean [relative] [h]umid-ity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sun-shine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
86.2	25.0	S.W.	12.6	0.0	0	0	94	....	....	....	1
85.8	24.5	S.E.	3.4	9.2	10	5	00	....	....	. .	2
....	....	S.W.	1.1	....	..	..	90	....	....	....	3 ....SUNDAY
78.8	26.0	E.	4.2	2.0	10	0	85	....	....	....	4
78.3	29.2	N.	2.8	10.0	10	10	00	Inapp.	....	....	5
88.8	31.7	N.W.	12.2	10.0	10	10	00	0.20	3.3	0.53	6
96.2	29.8	W.	21.7	10.0	10	10	00	0.14	5.4	0.68	7
88.3	19.2	W.	38.1	10.0	10	10	00	....	1.6	0 16	8
86.0	17.2	W.	36.2	10.0	10	10	00	....	0.1	0 01	9
...	....	W.	27.0	....	..	.	00	....	0.3	0.03	10 ....SUNDAY
68.2	13.5	W.	18.8	5.3	10	0	56	....	0.4	0.00	11
83.7	22.7	S.W.	12.7	9.3	10	0	00	....	0.3	0.03	12
68.0	22.0	S.W.	28.7	8.0	10	0	24	Inapp.	Inapp.	0.00	13
58.7	5.0	W.	14.5	2.2	10	0	99	....	.. .	....	14
73.3	18.5	N.E.	11.1	4.7	10	0	75	....	....	....	15
74.7	23.0	N.E.	18.4	2.5	8	0	94	....	....	....	16
...	....	N.E.	25.3	....	..	..	08	0.08	0.9	0.17	17 ....SUNDAY
86.7	29.0	N.E.	13.4	10.0	10	10	13	Inapp.	1.9	0.19	18
79.5	27.5	N.	5.5	10.0	10	10	06	....	....	...	19
79.2	28.3	N.E.	23.7	9.5	10	2	12	....	....	....	20
63.2	20.3	N.E.	29.5	4.7	10	0	80	....	....	....	21
54.3	20.5	N.E.	13.5	3.7	10	0	93	....	....	....	22
65.5	27.7	S.W.	29.5	2.8	8	0	92	....	....	....	23
...	....	S.W.	24.5	....	..	..	07	0.07	Inapp.	0.07	24 ....SUNDAY
59.0	10.3	N. E.	13.7	0 2	1	0	98	....	....	....	25
64.7	8.8	E.	9.4	7.5	10	0	36	...	....	....	26
75.0	26.5	S. E	15.6	6.7	10	0	21	0.10	....	0.10	27
78.2	26.5	S.W.	21.6	6.3	10	0	15	0.03	....	0.03	28
75.3	22.2	S.W.	19.2	8.2	10	0	27	....	1.1	0.11	29
62.7	7.7	S.W.	17.3	1.5	7	0	96	....	....	....	30
....	....	S.	12.8	....	..	..	19	....	...	....	31 ....SUNDAY
75.3	21.6	......	17.36	6.32	..	..	40.0	0.62	15.3	2.11	Sums ....
75.9	....	....	....	6.17	..	..	¶45.5	0.88	26.5	3.53	15 years means for and including this month

*Barometer readings reduced to sea-level and [te]mperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 48.9 on the 22nd; the great[es]t cold was 7.8 on the 26th, giving a range of [te]mperature of 36.1 degrees. Warmest day was [th]e 23rd. Coldest day was the 14th. Highest baro[m]eter reading was 30.508 on the 1st; lowest baro[m]eter was 28.982 on the 7th, giving a rangeof 1.521 [in]ches. Maximum relative humidity was 100 on [th]e 7th. Minimum relative humidity was 41 on [th]e 22nd.

Rain fell on 9 days.
Snow fell on 12 days.
Rain or snow fell on 14 days.
Auroras were observed on three nights.
Hoar frost on five days.
Solar halo on two day.
Lunar halo on two nights.
Lunar corona on one night.
Fog on three days.

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Rejected articles will be returned if desired, and if stamps are **enclosed** for that purpose. The editors will not hold themselves **responsible** for any views expressed by authors.

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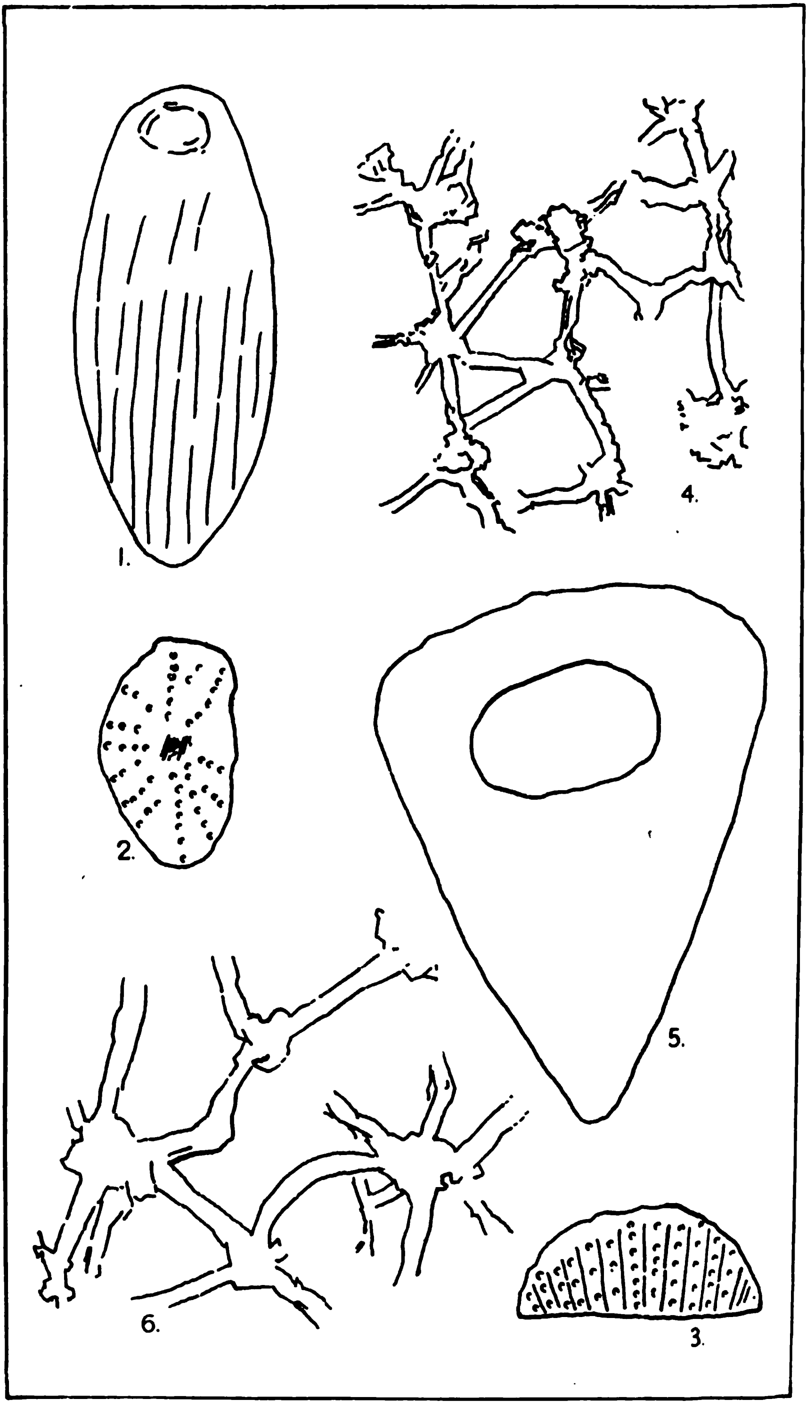
SPONGES FROM THE TRENTON LIMESTONE AT OTTAWA



L. M. LAMBE, DEL.

THE

CANADIAN RECORD

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VOL. III. JULY, 1889. NO. 7.

On the Cambrian Organisms in Acadia. *

By G. F. Matthew, M.A., F.R.S.C.

[*Abstract.*]

The earlier papers describing the Cambrian animals of Eastern Canada, read by the writer, before this Society, have related to the fauna of the St. John (or Acadian) group, but having lately made examinations of the measures which underlie the Paradoxides beds, he has found evidence of a physical break below these beds, and that the underlying beds carry a different fauna. This fauna is very imperfectly exhibited, but is sufficiently developed to show that this lower, or basal series is the equivalent of the blue clay of Russia and the Eophyton sandstone, &c. of Sweden.

Late developments in the palæontology of the oldest Cambrian beds, show that the Olenellus beds of the State of New York and elsewhere, are of about the same age as these old Acadian beds, and indications of the Olenellus fauna have been found by me from the middle of this basal series upward to the Paradoxides beds.

* Read before the Royal Society of Canada,——May, 1889.

In the lower part of the Basal or Georgian series have been found worm tracks, casts and burrows, referred to in a communication to this journal. Of lower organisms, sponges are well represented. Remains of basket sponges (Euplectellidæ) are quite common in the finer beds. Of these, beside the sponges with regular transverse bars, there are others which possess an irregular mesh with diagonal and forked spicules. Another family of sponges is represented by forms with a thick parenchyma and numerous irregular loculi; the oscules in these sponges are sometimes arranged with an approach to a regular order, but more frequently they are irregular. A third family (probably) of sponges has left skeletons of small rods in which no spicules have been found, these are studded with minute elevations marking the place of denser globular masses in the body.

Certain minute bodies with the sponges appear to be Radiolarians, some are club-shaped, others globular, and one is oval with a raised hexagonal ornamentation.

The flora of this series consists of sea-weeds. One of the oldest of these, a Palæochorda, is found in the lowest sandstone beds, where it is associated with the remains of sponges; although a plant of such great antiquity, it is comparatively highly organized in the structure of the stem, to which large jointed setæ were attached.

In the arrangement of its barren fronds, another interesting species recalls the *Fucoides circinnatus* of Brongniart, but in the Acadian species, the branches are flat, and not round, as those of that species are said to be. The Acadian species had narrow, fertile fronds, bearing spikelets (stichidia) after the manner of some of the red sea-weeds.

Brachiopods so far, appear to be rare in this series of beds; there is however, near the middle of the series, a large one having the appearance of an Obolus, and resembling the *Mickwitzia monilifera*, Schmidt, (*Lingula?* or *Obolus? monilifera Linrs.*), but apparently distinct.

Undoubted examples of *Platysolenites* of Pander, a crinoidal genus of the Blue Clay of Russia, have been found with this brachiopod.

ORGANISMS OF THE ST. JOHN OR ACADIAN GROUP (SERIES).

Fauna and Flora of Division (*Stage*) 1.—(Paradoxides Beds).

The fauna of Band *b* of this stage, resembles in many respects that of the series just described. There is the same prevalence of sponges. The basket sponges and the rod-like sponges (?) are common to both, but the latter here attain a much larger size, and are more plentiful. In all the fine layers of this band, traces of Protospongiadæ may be found, but no examples of the typical Protospongias of the Paradoxides beds have been observed. The Protospongiadæ of this band have either a minute rectangular reticulation, or the mesh is coarser, and crossed by large diagonal and branching spicules. Even the sandstone beds of this band exhibit numerous fragments of spicules.

The brachiopods are represented in this band by several genera, some of which have been already described. This paper contains descriptions of additional species—an Obolus, a Lingulella, and three species of Leperditia.

The Algæ are present in several different types, among which are a Buthotrephis, and a microscopic form parasitic on the larger organisms. This little thing spread itself in a minute network over the mud of the sea bottom, by jointed filaments, which at their intersection formed enlarged nodes. There are also some quite small oval forms of dark color resembling Hydrocystium, which may have been algoid.

Among the new species of the Paradoxides beds is a little Platyceras. New facts have been obtained, relative to the smaller Stenotheca, to *Lepidella anomala* and to two species of the Paradoxides that have been described: *P. pontificalis* is found to be a narrow, and *P. Micmac* a broad form of *P. Hicksii.*

Fauna of Division (*Stage*) 2.—(Olenus Beds).

Abundant remains of large Protospongia are found in these beds. Among them are *Protospongia fenestrata,* Salt,

Protospongia (?) cf. *major* Hicks and another large species, whose branches or cups were ten inches or more in length. These large sponges must have lived in quite shallow water, as they are found bedded between ripple marked sandy layers.

Many of the beds of this division abound with the tracks, burrows and casts of worms, among which are a Monocraterion, whose straight ray-like tracks spread from the burrow, a distance of eight or ten inches. Two species of Arenicolites are common, one quite small, another larger with a space of one to one and a half inches between the burrows. The cast of the gallery of this species, seen from below, greatly resembles Mr. Billings Arthraria, as the gallery is enlarged a little at each extremity; and short examples thus look somewhat like dumb-bells.

Among fossils which appear to have their place in the upper part of Division 2, are some that have been found in the Kennebecasis basin of Cambrian rocks. These are *Leptoplasti* one allied to *L. stenotus*, Ang. *Agnostus pisiformis*, var. and *Agnostus Nathorsti*, var. The association of these trilobites would indicate a horizon at the top of this division.

Fauna of Division (*Stage*) 3.—(Peltura Beds).

The species which indicate this horizon are two species of *C. tenopyge* (cf. *C. flagillifer* and *C. spectabilis*,) *Orthis lenticularis* and a *Kutorgina*, these occur in the middle of this division. At the bottom of the division *Lingulella lepis* is found, and another larger species (*L. ampla*, var ?)

Beds in Cape Breton corresponding to this stage, have *Peltura scarabeoides*, *Sphærophthalmus alatus*, and *Orthis lenticularis*.

Fauna of Arenig Group (*Ordovician*).

This horizon is indicated by certain fossils lately discovered in the St. John basin, at the summit of the Cambrian measures.

They consist of graptolites of the genera Bryograptus, Tetragraptus and Dichograptus, with a large Orthis and a Cyclognathus

The physical history of this part of Canada, in Cambrian times as shown by the Cambrian terreins in southern New Brunswick, was briefly as follows:

The basal series is marked throughout by the waning effects on its sediments of the eruptive activities of the preceding age. The series is variable in thickness, the conglomerates have some closely cemented breccias as well as the ordinary rubbly conglomerates of sedimentary origin. Occasional thin beds of felsite and petrosilex are found, and the finer sediments have a strong green or red tint, and are more or less charged with iron.

In the St. John group, the rocks of Division 1 show a gradual deepening of the sea without disturbance; and without any trace of eruptive activities after the first few bands were laid down.

When the second division of the St. John group was being deposited, the sea-bottom again came up to the surface, and was awash, or was under a thin covering of sea-water throughout this stage.

At the beginning of the third stage, the land again sank, and continued under a considerable depth of water throughout the whole of this age, as we see from the great body of fine dark grey slates, which form the bulk of the measures of this division.

Finally the sea-bottom sank deeper still, and in tranquil waters, comparatively free from currents, lived the graptolites which we now find buried in the soft carbonaceous mud (now changed to slate) found to have been deposited in this region after the close of Cambrian time.

Notes on the Lake St. John Country,

By E. T. Chambers.

The Lake St. John region is about one hundred miles north of the city of Quebec, and has for the last two years been the subject of much attention, from the fact that it contains a large amount of very fertile land, and has a climate remarkably mild for such a northern situation,—a fertility and temperature much better than is enjoyed by the settlers around the old fortress city, and nearly equal to that of Montreal. Separated from Quebec by the Laurentian Mountains, the tedious journey was a great hindrance to its settlement, but during the last five or six years a first-class railway has been constructed from the old capital to the very borders of the lake. This, after running some forty miles westward to the pretty town of St. Raymond, in the fertile valley of the St. Anne river, turns to the north, boldly making its way through the midst of the mountains, and after a course of 137 miles more, reaches the town of Chambord near the Lake St. John. A branch line of five miles goes to the mouth of the Metabetchouan where a steamboat is able to come close to the shore. A few notes on this somewhat remarkable route and on the lake itself may be, perhaps, of some interest.

After leaving the alluvial clay of the river St. Charles at Quebec, the track has a somewhat steep incline of 132 feet in the mile. At St. Ambroise, about ten miles from Quebec, it passes through the post-pleiocene in a cutting, and two or three years ago, before they were overgrown with herbage, the banks on each side exhibited a large deposit of shells of *Saxicava rugosa* and *Mya truncata*, chiefly of the former, and in such quantities that the banks were quite white. I am told by the railway people that the elevation here is 533 feet above the St. Lawrence. Soon after this the line passes through a marshy country, but a few miles after leaving St. Raymond, comes upon the grey Laurentian gneiss, which appears to form the mass of the mountains till we reach Lake Bouchette, about twenty miles from Lake St. John. This gneiss varies much in the size and

arrangement of its constituents. Here it is seen with the ingredients pretty equally mixed, forming a granite; in another place, the components are in regular layers, again these layers are bent and contorted in every possible way. In many places the mountains are much shattered, broken into larger and smaller masses as if by some violent explosion; sometimes these large masses present a very threatening appearance as the train rushes along under them, so slightly do they appear to be supported.

At about sixty-five miles from Quebec, the line of railway comes to the east side of the River Batiscan, and continues its course along the sides of the mountains forming its bank for nearly thirty miles. The scenery along this river is singularly beautiful. The Batiscan, about 150 yards wide, in this part of its course is an alternation of foaming rapids, some of them cascades, and stretches of less boisterous, beautifully clear water running between high mountains, clothed, except where too steep, with arborescent verdure from the river to the summit. As the track rises—and there are some very steep grades in this part—the mountains increase in elevation, some of the highest rising to the height of 1500 or 1600 feet (perhaps more) above us. Towards the south their shape is a sort of elliptical curve, on the north side they are nearly perpendicular and show bare surfaces of rock some hundreds of square feet in extent.

The whole of the country abounds in lakes. It is said that in a rectangle reaching in length from Quebec to Lake St. John, and twenty miles wide, 500 lakes have been counted by the railway surveyors. Several of these are large. Lake Edward, or Lac des grandes iles, is twenty-one miles long, and seven and a half miles wide, and contains many large islands, which, with the hills which encircle the lake, are covered with forest, healthy trees, in no place disfigured by the black half-burned stumps which so often spoil the beauty of our woodlands.

Near Lake Kiskisink or Cedar Lake, the railway crosses the height of land between Quebec and Lake St. John, its

elevation being 1504 feet above the St. Lawrence. The land here is very sandy, so exceedingly fine and white in some places that I think it might be employed in glass manufacture. Around this lake the country is so covered with blocks of gneiss, that nothing grows under the trees but ferns, lichens and mosses; I looked in vain while here for a blade of grass.

Lake Kiskisink is about four and a half miles long, and is the source of the River Bostonnais, a tributary of the St. Maurice. About a mile and a half east of the lake is the Metabetchouan river, which, rising a few miles to the south east, flows into Lake St. John. Most of the journey northward from Cedar Lake is down a steep incline. As the Lake (St. John) is approached, the larger size of the trees, the more healthy vegetation and signs of successful cultivation give evidence of a more genial and fertile region. Near the lake we may perceive in the railway cuttings, the same grey gneiss, but here and there is red gneiss, the crystals of red orthoclase of large size, and in some places boulders of Labradorite.

From Chambord to the western extremity of the lake, and apparently extending under its bed, filling up a depression in the Laurentian, are beds of Silurian limestone. These beds appear to have been but little disturbed, and lie in a nearly horizontal position, the bed of the lake having a very gentle slope from the shore. The limestones appear to be formed entirely of fossil-shells. These are scarcely discernible in freshly broken pieces, but in places on the borders of the lake, especially in front of the town of Roberval, south of the River Ouiatchouanish, the weathered surfaces of the limestone forming the beach exhibit very fair examples of Trenton fossils, among them *Murchisonia*, *Pleurotomaria*, *Halysites* and others, characteristic of this formation. These fossils are protruding from the upper surfaces of slabs, generally two or three inches in thickness. So plentiful are they that the difficulty lies not in the finding, but in the selection of the most perfect or most characteristic specimens. This exposure seems to extend about two and

a half miles. Among the specimens I collected here were the following:—

Columnaria Alveolata.	*Murchisonia bicincta.*
Petraia.	*Murchisonia gracilis.*
Rhynconella.	*Murchisonia holopae.*
Maclurea Logani.	*Metoptoma erata.*
Straparollus (?)	*Bellerophon Argo.*
Pleurotomaria.	*Orthoceras.*

The most interesting however, was a large fossil some twelve inches long and eight inches in diameter, spheroidal in form, apparently consisting of a number of concentrically laminated masses, and somewhat resembling *Stromatopora.* It lay near the bank, and might have been washed up from the lake by the storms of winter, or had perhaps been left near its original position; its great weight, and hard imperishable nature having resisted the forces by which the more perishable rock-bed was washed away. Sir William Dawson has come to the conclusion that this is a new species of Cryptozoon and has named it *Cryptozoon boreale.*

It is probable that a description of this will be given by Sir William Dawson in a future number of the *Record.*

The dip of the strata is toward the lake. At Point Bleu, the limestone has a rough crystalline form, is in layers from an inch to nearly a foot in thickness, and forms a cliff ten to twelve feet high. The shore is strewn with large slabs, but weathered fossils do not appear as at Roberval. At Snake Island towards the south-west of the lake, characteristic fossils of the Hudson River group are said to have been obtained.

In a paper read in 1882 before the Royal Society of Canada, the Rev. Abbé Laflamme stated that he had found the Trenton limestone well developed upon the shore of the Saguenay River, from St. Anne to the upper side of the junction of the two discharges. He had also discovered some beds of the same south-east of the mouth of the Metabetchouan, reposing on the Laurentian, and showing signs of being the remains of larger deposits of which

the greater part had been removed by glaciation. He noticed that these limestones are rich in petroleum; this has been observed by others also, for in answer to enquiries recently made, I find that a gentleman of Buffalo has purchased land near Chambord with the intention of bringing the petroleum there into use.

Lake St. John is 300 feet above the level of the Gulf of St. Lawrence, it is not, except towards the centre, very deep, and having sandbanks in some parts, navigation near the shore is difficult. In shape it is almost circular. Its greatest diameter from the Metabetchouan to the Peribonca is twenty-eight miles, and from the grand discharge at the head of the Saguenay to the Ouiatchouanish twenty miles. It is the recipient of several rivers, large and small, draining a great extent of country. On the north it receives the Peribonca, said to be nearly 400 miles long, and navigable for nearly twenty miles. The Mistassini and the Ashuapmouchouan navigable for eight miles coming from the north-west. On the south of the lake are the Ouiatchouan, leaping over and down the mountain side in magnificent and beautiful falls, which give the name to the river, and which are 236 feet in height, and the Metabetchouan from Lake aux Rognons, a few miles south-east of Cedar Lake. This river is said to have a fair amount of good land, suitable for settlement on its borders.

As is well known, Lake St. John discharges its surplus waters by the Saguenay river into the St. Lawrence.

It would appear as if Lake St. John occupies a hollow formed by the elevation of the Laurentian hills in this part. That in the Palœozoic times it was, with the country around, covered by the Silurian seas. After these retired, this part of the country was not much disturbed by the various movements which occurred in many other regions. In the glacial period, it was with the rest of this part of the continent again submerged, and much of the limestone carried away. The bottom of the lake and parts of the country around have retained the covering of Silurian limestone and the decay of this, mixed with the disintegrated

constituents of the Laurentian rocks, forms the fertile soil which makes this district of so much importance to the province. About twenty years ago, one of the largest bush fires on record devastated the whole country on the south of the lake from the Descharge to Point Bleu. Many poor habitants lost their lives in this conflagration. The burnt country soon attracted fresh settlers, and being now more easily cleared, and possessing such good soil, this part is the most thickly populated. From the comfortable appearance of the people and their homes, the well-fenced fields and fine crops of wheat, oats, barley, potatoes, &c., it is evident that the praise bestowed on this region is no more than it deserves. There is said to be another flourishing settlement on the western side of the lake on Ashuapmouchuan. At the Indian reserve at Point Bleu there is a settlement of Montagnais Indians, pure Indians, veritable hunters. Houses have been erected for them, but they prefer living in their tents, using the houses as repositories for their various belongings. They go into the woods in the winter, seeking furs, and are said to endure great hardships being often in want of food when game is scarce. Indeed, it is said, many have died of starvation. The young people are, as a rule, healthy looking and round faced, but the older people carry signs of their hard life in their bent forms and hollow cheeks. It may be noticed that very few old men are seen among them.

As a consequence of the great fire, the trees on the south side of the lake are but small. On the north side and in the country around the Saguenay, lumbering operations have been for many years carried on by the Messrs. Price, Brothers, of Quebec, and most of the valuable timber taken out. The principal trees are spruce, balsam, white and yellow birch.

Leaving Lake St. John and turning southward, with the exception of some good land on the Metabetchouan river, there appears to be little to entice the settler till you approach St. Raymond. Other fertile spots may be found when the country is better known, but at present the

chief wealth of the district seems to be in its white and yellow birch, spruce and balsam, and in the more southern parts, elm and maple. Mills have been erected on some of the streams, and quite an extensive business is done by the railway in conveying the sawn lumber, as well as immense quantities of cordwood to Quebec.

There seems to be but little chance of minerals of any value being found there. It is said that copper and iron have been reported at Beaudet Station, and at Valcartier is a deposit of foraminiferous earth. I have before spoken of the petroleum at Lake St. John. The granite or gneiss in some parts, is fine in grain and hard. It makes a good polish, and is not affected by the weather. It is to be used for the monument to Jacques Cartier to be erected at Quebec.

Large animals are scarce throughout the whole of the district. Bears may sometimes be seen near settlements. The beaver, otter, musk rat, fisher and mink are found. It is the fish which make the country so interesting to the sportsman, and which is drawing the attention of our neighbours to this part of our province. In this region of mountain streams, lakes and rivers, there is scarcely a piece of water but abounds with fish. In Lake St. John is found the famous Ouinaniche or land-locked salmon, weighing from 4 to 14 lbs. It is a beautiful fish, fine eating, and said to give excellent sport to the angler. Other kinds of fish of good size are found here also. In other streams and lakes are the forked tail and speckled trout, the former weighing up to nearly 30 lbs., the latter to 7 or 8 lbs. Fine fish of 3 lbs. or 4 lbs. are quite common in Lake Edward. Other fish found there are bass, doré, whitefish, pike and perch.

On a New Genus of Siliceous Sponges from the Trenton Formation at Ottawa.

By George Jennings Hinde, Ph.D.

[Plate D.]

The Canadian Geological Survey, through Mr. J. F. Whiteaves, F.G.S., has lately forwarded to me, for examination and description, a small collection of fossil sponges which has been obtained by Mr. W. R. Billings from the Trenton Formation at Ottawa. The rarity of these organisms in this geological horizon renders a special interest to their study. The forms obtained are, for the most part, unattractive in outward aspect, showing little more than their cylindrical or compressed outlines; and their real characters, whether sponges or mere inorganic nodules, cannot in all cases be known until sections have been made. These show that the sponges are now completely filled up by the dark limestone matrix of the rocks in which they occur, which renders it very difficult to make out the direction of the canals which traversed their walls. Sometimes, however, transparent calcite has partially occupied the canals. The delicate spicular network of which the sponge-skeleton is composed, has also been largely destroyed in the fossilization, and the portions which remain have quite lost their original siliceous structure, and are now replaced by crystalline calcite. The effect of this change has been that the definite form of tho individual spicules and their mode of union with each other, can no longer be recognized, and thus render their determination somewhat uncertain. In spite of these hindrances to a precise diagnosis, I venture to describe these forms as a new genus of Lithiotid sponges, for which I propose the name Steliella[1].

Steliella, g. n.

Generic characters.—Sponges simple, subcylindrical, compressed, club-shaped or occasionally funnel-shaped, appar-

[1] *στηλη*, an upright stone or post, dimin.

ently free. Walls thick, a cloacal depression at the summit, which may be extended downwards as an open tube. The outer surface of the wall with circular canal apertures disposed in longitudinal rows. There are two series of canals; a larger which traverses the walls in a generally vertical or oblique direction; and a smaller which extends from the surface in an arched direction to the interior of the sponge wall. The skeleton consists of a connected spicular meshwork, apparently of the Anomocladina type, in which there is a relatively small central node with a variable number of rays which connect with adjoining nodes. No distinctive dermal layer is present.

The spicular structure of this genus is nearest allied to that of *Astylospongia*, F. Roemer, but the nodes are less developed, and the network is much less regular. Owing to the manner in which the spicules are replaced, and their coalescence, it is impossible to make a close comparison with other sponges, and, in fact, it is difficult to state positively whether the spicules are uniformly of the Anomocladina type. The canal apertures of the surface, and the shape of the sponges as well, resemble some forms of *Calathium*, Bill., such as *C. Anstedi*[1] and *C. Fittoni*,[2] but the spicular structure in these latter is as yet unknown, and therefore they cannot properly be compared with *Steliella*.

STELIELLA BILLINGSI, sp. n., pl. Figs. 1–4.

Sponges subcylindrical or compressed so as to be nearly elliptical in transverse section, or club-shaped; the basal end obtusely rounded and apparently free. The specimens vary from 28 to 64 mm. in length, and from 14 to 34 mm. in thickness. The vertical rows of canal apertures are about 1 mm. apart, the apertures themselves, in the single specimen in which they are clearly shown, are circular or ovate and about 1 mm. in width. The larger canals, as shown in transverse sections, are from 0.5 to 1 mm. in width, those of the smaller series are from 0.2 to 0.3 mm,

[1] Pal. Fos., vol. 1. p. 210.
[2] Ib., p. 211.

wide. The skeleton of the sponges has the appearance in thin sections of a minute stellate network, the central nodes rounded or slightly elongate, from 0.11 to 0.17 mm. in thickness; the spicular rays are about 0.3 mm. in length and 0.03 in thickness; there are from three to six radiating from each node, but they cannot in all cases be traced to their union with the proximate nodes. In some cases the spicular rays radiate from a non-inflated centre and are thus of a tetracladine type; such forms however appear to be exceptional.

This species appears to be not uncommon. The specimens are all alike in their unfavourable condition of preservation. In several, the cloaca and main canals have been partly filled with microscopic crinoidal joints.

Distribution. Trenton Limestone, Ottawa. Collected by Mr. W. R. Billings, after whom the species is named.

STELIELLA CRASSA, sp. n., pl. Figs. 5–6.

The single specimen referred to this species is funnel-shaped, with an oblique summit and thick rounded margins. The basal extremity is obtusely rounded. Tho cloacal depression appears to be shallow. There are only a few traces of canal apertures on the outer surface, they are about 1 mm. in width, their arrangement cannot be ascertained. The specimen is 65 mm. in height, and 30 mm. in thickness. The large canals are about 1 mm. in width, those of the smaller series vary from 0·25 to 0.5 mm. wide. The spicular structure is of the same character as in the preceding species, but the rays of the spicules are decidedly larger, ranging up to 0.5 mm. in length, and the spicular mesh is thus of a more open character.

The specimen is in the same state of preservation as the forms described above.

Distribution. Trenton Formation, Ottawa. Collected by Mr. W. R. Billings.

REFERENCE TO FIGURES.

Figs. 1–4 *Steliella Billingsi.*

Fig. 1. Showing the form of the sponge and traces of the vertical ridges between the canal apertures.

Fig. 2. A transverse section from the centre of the same specimen showing the arrangement (in section) of the large canals. Natural size.

Fig. 3. The outer surface of another specimen showing the canal apertures. Natural size.

Fig. 4. A portion of the spicular mesh, as seen in a thin microscopic section. Enlarged sixty diametres.

Figs. 5–6. *Steliella crassa.*

Fig. 5. The sponge, natural size.

Fig. 6. A fragment of the spicular mesh, enlarged sixty diameters.

ON THE ACADIAN AND ST. LAWRENCE WATER-SHED.

BY L. W. BAILEY.

Read before the Nat. Hist. Society of New Brunswick, April, 1889.

The tract of land which constitutes the great divide between the basin of the St. Lawrence on the one hand, and shore of the upper St. John and Baie Chaleur on the other, is one of much interest for several reasons. Geographically it corresponds very nearly to the line separating the Provinces of New Brunswick and Quebec; politically, it has had great significance in connection with the various international and inter-provincial boundary disputes, as it still marks in a general way the line of separation between races of different language, customs and descent; physically, its character is such that, until a comparatively recent period, it has acted as a very serious barrier to inter-provincial communication; and finally, from a geological point of view, it is of interest as forming a portion of one of the great cordilleras of the continent, the eastern extremity of the great Appalachian mountain-system. It is proposed in the present paper, to give a brief summary of some of its characteristics, as viewed in the last two aspects.

Regarding the Gaspé peninsula and its direct extension westward, as properly marking the limits of the area under discussion, this may be said to have the general form of a broadly curving belt convex to the northward of which the sides are nearly parallel and at a distance from each other of about ninety miles, while its length from Cape Gaspé to the Little St. Francis river, is 250 miles. While on the northern side it forms the south shore of the St. Lawrence, and is of very regular outline, it is on the southern side less clearly defined by the valley of the St. John river above Edmunston, and farther east by that of the Restigouche river and the Bay Chaleur.

Though everywhere hilly, the district in question can only at comparatively few points be properly described as mountainous. Its true character is rather that of an elevated plateau, having in the Gaspé peninsula an average elevation of 1000 feet, but declining to the westward, upon which are held up, along certain lines, somewhat more prominent ridges, while the sides have been broken up and made hilly by the effects of deep and irregular erosion. Of the ridges referred to, the most considerable are those forming the Shickshock Mountains, included wholly within the Gaspé peninsula, and having a length of about sixty-five miles with a breadth of from two to six miles, at a distance of about twelve miles from the St. Lawrence. Their maximum elevation is from three to four thousand feet, and the district which they form is one of an exceedingly rugged but picturesque character. From the summit of Mount Albert, nearly 4000 feet high, not less than (158) one hundred and fifty-eight distinct peaks were observed and triangulated by Mr. A. P. Low, who also describes the intervening valleys as having often the character of deep cañons, traversed by narrow but deep streams with numerous rapids and falls. In addition to the main chain of the Shicksocks, a second range, of less elevation, but still including some lofty peaks, is found between the latter and the coast, while here and there, on either side of the axis, are isolated granite hills, such as Table Top Mountain, rising fully 2000 feet above

the general level of the surrounding country, and nearly bare of vegetation. Towards Lake Metapedia and the line of the Intercolonial Railway, the great ridges of the Gaspé peninsula become much less prominent, but a little to the westward of the lake, another range, that of the Notre Dame Hills, rises somewhat abruptly from the surrounding plateau, and stretches away in the direction of the head-waters of the Grand Metis and Patapedia rivers. It does not, however, quite reach these latter, and to the westward of these streams no ridges of a well defined or continuous character are to be met with.

The rivers which drain as well as owe their origin to the great belt of high land here described, present many interesting features. They are quite numerous, including, in the Gaspé peninsula proper, the St. Anne des Monts, the Dartmouth, York and St. John at the eastern end of the peninsula, with the Grand Pabos, Bonaventure, Big and Little Cascapedia, tributary to the Bay Chaleur. Farther west we have, on the north or St. Lawrence side, the Little and grand Metis, the Rimouski, the Trois Pistoles, Riviére Verte and Riviére du Loup; while on the southern side, besides the Metapedia, there are the Restigouche, with its tributaries the Patapedia and Quatawamkedgwick, the Madawaska, the St. Francis, the Big Black and Little Black rivers, with others of minor importance. As might be expected, the streams flowing northward into the St. Lawrence are, as a rule, much smaller than those flowing in the opposite direction, but if we include the entire distance of the latter to the sea, the contrast is in some instances quite remarkable. Thus while few of the streams tributary to the St. Lawrence show a greater length than thirty miles, the length of the Metapedia, including the lake, is nearly sixty miles, that of the Restigouche from the source of the Kedgewick nearly ninety miles, and the St. John, measured in the direct line from Temiscouata to the Bay of Fundy, 260 miles, or from the source of the St. Francis, over 300 miles. The streams on the north shore also differ in being usually more irregular in course, with more

numerous and larger falls and rapids, being sometimes inaccessible for considerable distances. A more curious and more interesting feature is the fact that many of the streams, on either side of the general water-shed seem to have been but little affected by the position of the latter, having their source upon one side of this and their discharge upon the other. Thus in the Gaspé peninsula, as described by Richardson and others, the Matane, the Ste. Anne des Monts and the Chatte all take their sources south of the general height of land, and have cut deep gorges through the latter on their way to the St. Lawrence, while one branch of the Matane, rising north of the axis, flows across the latter to its junction with the main stream, and thus has its waters twice intersect the principal range of elevations. On the other hand the St. Francis, rising in a lake of the same name, is only twelve miles distant from the St. Lawrence, and several miles north of the sources of the Trois Pistoles, and yet flows southward across the range to its junction with the St. John.

Another noticeable feature is the number, size and depth of the lakes connected with the streams draining the southern side of the water-shed. Of these, Lake Temiscouata is the largest, being about thirty miles in length, with a breadth varying from one to two miles, and a depth (which is nearly uniform through a large part of its length) of 220 feet, its elevation above the sea being 467 feet. Lake Metapedia has an area of twelve square miles, about half that of Temiscouata, and an elevation of 480 feet, but has much less depth. Near Temiscouata, and in connection with it, are the Squatook Lake and Cabano Lake, both remarkable for their depth, while farther west, on the line of the St. Francis, are Pohenagamook or Boundary Lake, Glazier's and Beau Lake. It is noticeable that most of these lakes occupy long narrow troughs having a nearly north and south course, or transverse to the trend of the hills in which they lie, and that this course is extended in nearly the same direction by the streams to which they give origin. The valleys of these streams, as in the case of the Metapedia

and the Madawaska, are now largely filled with drift, and there can be but little doubt that all of them mark old channels of sub-aerial erosion, the partial damming of which has originated the lake-basins which now characterize them.

The climatic features of the region under review may be readily inferred from its position and physical aspects. While its comparatively high latitude determines great inequality in the length of the seasons, a long winter and a very short summer, its altitude further tends to reduce the mean temperature of the latter. The temperature of the coastal waters, these being a part of the great southward flow from the Arctics, being also very low, leads to a further chilling in the air above them, and the effects of this are readily recognizable in the prevailing winds. Fogs are not uncommon, even over the higher portions of the district, and the rain and snow fall both excessive. Ice sometimes remains in Lake Metapedia as late as the 24th of May, and upon the adjacent hill tops, as well as in ravines and gullies, great banks of snow often linger far into June. Frosts come early in autumn, and may come, even with severity, at any time of the year. Long continued and excessive heats are of rare occurrence.

The climatic features of the region are reflected in its vegetation and animal life, although the former is also largely influenced by the character of the soils and drainage, as these in turn are by the nature and structure of the rocks beneath. The larger portion of the district is forest-clad, the clearings being for the most part confined to a narrow belt, five to fifteen miles wide, skirting the St. Lawrence, to isolated settlements around the shores of the Gaspé peninsula, to the immediate neighbourhood of the Temiscouata Portage Road, and to the more recently opened line of the Intercolonial Railway. The trees most commonly met with are spruce, fir, hackmatac and white birch, but in favorable situations and on lands of moderate elevation yellow birch and sugar-maple are also not uncommon, and along the river valleys, groves of black ash and poplar.

The immediate banks of streams are bordered by the ubiquitous alder, amid which in autumn glow the rich berries of the mountain ash. On the higher summits the vegation is of course more scanty, and in the Shickshocks, as already described, these are often quite bare of trees. Of herbaceous plants there is, of course, in the district as a whole, a considerable variety, but little has yet been done in working out the details of their distribution. Of those occurring in the vicinity of Lake Temiscouata a pretty full list has been published by Mr. J. J. Northrop (Bull. Torr. Bot. Club, Nov., 1887), and supplemented by another prepared by Mr. Ami of the Geological staff. With few exceptions the species named are the same as those found in the valley of the St. John river, but many forms, both of trees and herbs, common in the latter have not yet been noted in the hilly district to the north. The following list embraces a few forms observed by the author on the banks of the upper St. John, near Fort Kent, *Parnassia Caroliniana Tanacetum Huronense*, *Oxytropus Campestris*, *Veratrum viride Hedysarum boreale*, *Allium Shoenoprasum*, *Heracleum lanatum*, *Rosa blanda*, *Lilium Canadense*, *Potentilla fruticosa*, *Anemone Pennsylvanica*, *Thalictrum dioicum*, *Castilleia pallida*, *Silene inflata*, *Diervilla trifida*, *Lysimachia stricta*, *Brunella vulgaris*, *Pyrola secunda*, *P. elliptica.*

As to animal life, the same forms are found as occur in the less inhabited parts of our own province. Bears are very common, and red-deer and caribou but little less so, while moose are comparatively rare. Both birds and insects present considerable variety, but as yet have been but little studied. The remarkable clearness and coolness of the streams, and the depth of the lakes, are especially favorable for the development of fishes, and few regions in the world can excel in attractions for the sportsman, those afforded by the waters of the Restigouche and its tributaries, the Cascapedia, the Matane and the Grand Metis. In the larger lakes, in addition to trout, are found the white fish, the toque and the tuladi. Turtles, sometimes of large size, were often seen basking on the muddy banks of streams,

and at some points, specimens of cray-fish were also observed. The soils of the region under discussion can be best considered in connection with the geological formations which have determined them.

The oldest rocks of the Gaspé Peninsula proper, are, according to Mr. Ells, those which make up the mass of the Shickshock Mountains, and consist chiefly of epidosite, garnetiferous gneiss, horneblendic, chloritic and micaceous schists, together with large masses of serpentine, portions of which are distinctly stratified, while others suggest an eruptive origin. These rocks were described in the Geology of Canada, by Richardson and Logan, as being an altered portion of the Quebec group (Sillery), but are referred by Ells, chiefly upon lithological grounds, to the Pre-Cambrian. The only point where the belt of rocks so referred has been observed by the present writer is on the eastern shore of Lake Metapedia. They here consist of heavy masses of grey, greenish and purplish amygdaloid, holding considerable quantities of epidote, and bear some resemblance to the Huronian of southern New Brunswick, but not more than they also do to similar masses occurring in connection both with the Cambro-Silurian and Silurian formations. To the north of these volcanic rocks, upon the same lake, the rocks are chiefly hard massive sandstones of a greenish (or rarely purplish) color and distinctly bedded, but with these, at two points, are beds in which the sandstones, by the enclosure of limestone pebbles, become a coarse, gritty conglomerate. These rocks have also been referred to the Quebec group (Sillery) but they have as yet yielded no fossils, and further investigation of their relations is required. At the extreme northern end of the lake, the rocks are undoubtedly those of this latter group, and from near Sayabec Station on the Intercolonial Railway to St. Flavie, are exposed in a very remarkable and almost continuous section, showing repeated alternations of bright red, green, grey and black slates, with beds of massive grey or whitish sandstone. The former resemble the strata which at other points along the south shore of

the St. Lawrence have been described under the name of the Levis rocks, and the latter bear a similar resemblance to the so-called Sillery, but it may well be doubted how far these and the numerous other sub-divisions adopted by Richardson in his report on the geology of southeastern Quebec, are capable of being sustained by actual facts. A new and good opportunity for the study of these rocks has recently been furnished by the line of the newly opened Temiscouata railway, and was availed of by the writer and Mr. W. McInnes during the past summer; but with the result of showing that along this line at least no good reasons exist for the adoption of such sub-divisions. It has been supposed by Richardson that in addition to the several members of the Quebec group proper (Sillery, Lauzon and Levis) a portion of the sandstones found at St. Antoine and Frazerville (Riviére du Loup) are of Potsdam age, but it is impossible to see in what respects the rocks thus referred to differ either in character or relations, from those elsewhere referred to the Sillery sandstone. The topography of the country underlaid by these Quebec rocks is exceedingly broken and rugged, the repeated alternations of hard and soft strata, together with excessive folding, having been especially favorable to the formation of steep and bold ridges separated by narrow and deep valleys. The massive sandstones, from their peculiar whiteness and absence of vegetation, are especially conspicuous, but are exceeded in elevation, as well as in the craggy character of the scenery which they determine, by the hard and glossy slates which at various points rise from beneath them. Near the axis of the divide the land is, as has been stated, somewhat flatter, but here large tracts are so thickly strewed with blocks of the dark grey Sillery sandstones that little else is visible. In all parts, except where intervales occur, the soils are of the most meagre character, and the settlements, chiefly French, of the poorest description.

The transition from the Quebec or Cambro-Silurian rocks to those of the Silurian system, is everywhere well marked, being seen alike in the character and attitude of the beds.

The contrast in the latter respect is especially noticeable, for while the strata of the older series are everywhere highly inclined and sharply folded, those of the younger, along the line of contact, are very generally nearly flat. While, too, the former are largely made up of slates, often brilliantly or variously colored, and without conspicuous fossils, the latter are usually grey or dark grey in colour, consist largely of limestones, and abound in corals and other organic remains, often of large size. The contrast in many places has been made still more striking by the effects of erosion. Thus along a large part of its northern edge, the Silurian presents the appearance of a bold or even precipitous escarpment, separated only by a deep and narrow valley from the irregular and usually lower tract to the north occupied by the inferior group. This feature is very strongly marked between the Grand Métis river and the Rimouski, determining in part the eminence of Mount Commis and wholly that of the Bois Brulé, and though to the westward of the Rimouski it becomes less evident, it re-appears with special prominence at Temiscouata Lake, here originating the remarkable eminence known as Mount Wissick, Mount Lennox or the Big Mountain.

The order of succession and the equivalency of different members of the Silurian system in northern New Brunswick and adjacent portions of Quebec and Maine, have long been wrapped in much obscurity, the difficulty of their determination arising partly from the great sameness of the formation over large areas, the excessive folding and strong slaty cleavage by which it is generally characterized, and finally from the comparative paucity of fossils. An examination however of the section afforded by Lake Temiscouata and its vicinity has recently done much to remove this obscurity and to afford a key whereby the geology of the districts named may be more satisfactorily correlated not only with each other, but with more distant parts of the continent.

It will not be possible in this place to dwell at length on the details of this section (which will be fully described in

a forthcoming report, by the writer and Mr. Wm. McInnes, to the Director of the Geological Survey), but the following brief summary embodying the more important results, will probably be of interest.

The strata in question naturally fall into three groups. Of these, the first are those which directly constitute the eminence of Mount Wissick. At their base they exhibit a considerable thickness of a pure and nearly white highly vitreous sandstone, with thin beds of conglomerate, followed by a mass of shales partly grey and partly bright green and red, above which, forming the principal mass of the mountain, are thick beds of grey limestone, the whole having a thickness of about 600—1000 feet. Their dip is for the most part at a low angle and at the northern base of the mountain, where it rises precipitously from the lake, their unconformity to the Quebec group, consisting here of black and green slates which are highly disturbed and altered, may be readily witnessed. In the shales and limestones the fossils are abundant and large collections recently made show that with the possible exception of the sandstones at the base, the strata are newer than the Niagara formation, the lowest fossiliferous shales being about the equivalent of the Guelph formation of Ontario, above the Wenlock, but below the Ludlow group of England, while the higher range through this last named group to and possibly through the Lower Helderberg. A similar but less complete succession has been observed by the writer on the Rimouski river, in Bois Brulé Mountain at St. Blondine, in the valley of the Neigette, on Taché Road at St. Gabriel, on the Grand Metis, and finally on Lake Metapedia, and from each of these, fossils of similar character have been collected. On Lake Metapedia, the basal sandstones were also found to be fossiliferous, including among other forms that of *Pentamerus oblongus*, a *Murchisonia* and *Oriostoma.*

The second series of rocks shown in the Temiscouata section is separated from the last by an interval of about 800 yards without exposures, and differs greatly both in

character and attitude. The lowest beds are conglomerates of very coarse character, and attain a thickness of not less than 1000 feet, with a nearly uniform south-easterly dip of 50°. The pebbles in the conglomerates include many of limestone, and have apparently been derived from the disintegration of the slates and limestones of the Quebec group, but are not at present known to contain any fossils. Above the conglomerates is a considerable breadth of slates, also usually inclined southwards at high angles and including some beds of limestone, above which we finally have a great body of sandstone rock, peculiar, in addition to its hard and massive character, in being often of greenish or purplish color, with veins and blotches of epidote and bands of purple jasper. These rocks which form upon the lake the promontory of Point aux Trembles, and thence extend up the Tuladi river to Squatook Peak, which is composed of them, have been in earlier publications supposed to be younger than those of Mount Wissick and to be possibly Devonian. But collections of fossils recently made from both the slates and sandstones, and examined by Mr. Ami of the Geological Survey, would seem to show that they are really the older of the two, representing probably the lower part of the Niagara formation, and perhaps the Medina or Clinton group. From this it would also follow that we have here a great physical break in the Silurian system, its upper members being not only unconformable to the lower, but spreading beyond the limits of the latter, and thus made to rest directly upon the rocks of the inferior Quebec group.

The third and last group of rocks found at Temiscouata Lake consists of fine grained slates, with some sandstones of grey and dark grey colors, all of which are more or less calcareous, and are further noticeable for their repeated and complicated corrugations and the general presence of a very strong slaty cleavage. The direct contact of the slates with the sandstones of Point aux Trembles has not been observed, but from their general position in relation to the latter and from such fossils as have elsewhere been

obtained in them, it is conjectured that they are more recent than the latter. In this case they can not be far removed in age from the rocks of Mount Wissick, and are perhaps to be regarded as the equivalents of the latter, deposited under somewhat different conditions.

Applying now the key thus afforded, we find that the succession of rocks constituting the first of the above divisions, that of Mount Wissick, is but repeated, with eventually the same character and fossils, and with the same low dip all around the northern margin of the Silurian tract, from Rimouski to Lake Metapedia, and eastward into the interior of the Gaspé peninsula. So, similarly, to the southward of these strata, we find the country drained by the Restigouche and its tributaries, the Quatawamkedgewick, the Patapedia and the Metapedia, everywhere occupied by slates similar to those of the lower part of Lake Temiscouata and the Madawaska. At no point, however, distant from the lake, has anything been observed corresponding to any portion of the intermediate division, which must accordingly either be wholly wanting or concealed from view by the superposition of the higher and unconformable members of the system. In New Brunswick the slates are also predominant, being the prevailing rock through all the northern counties, though sometimes becoming so calcareous as to constitute true limestones, but with these, at a few points, are also found beds which appear to represent the inferior group. Thus on the Siegas River, in Victoria county, where the beds are nearly vertical, the slates are accompanied, first, by a coarse and very peculiar conglomerate (holding elongated, curved and disrupted pebbles of limestone, mingled with others of serpentine), and, secondly, by beds of sandstone not unlike those of Point aux Trembles, and carrying fossils indicative of a similar horizon. Again, on the Beccaguimec River in Carleton county, on the extreme southern edge of the Silurian tract, the succession of beds bears much resemblance to that observed near its northern edge, and again holds similar organic remains, while, finally, it is possible

that still another such area exists near the mouth of the Shiktehawk. In the State of Maine, the three groups of strata described are still more clearly represented, for while there, as in the province, the slates are the most commonly occurring rocks, comprising all the country drained by the upper St. John, as well as large areas about Presquile and Houlton, we have, in the Fish River Lakes, and again at Ashland, beds of limestone, abounding in fossils which are nearly parallel with those of Mount Wissick, while finally, in the valley of the Aroostook and covering large areas, are conglomerates and sandstones, which are the evident continuation of those of the Siegas River, presenting precisely similar characters and associations, and carrying the same fossils. In northern Maine, however, there are with these undoubted Silurian strata, great masses of volcanic rock, felsites, quartz-porphyries and amygdaloids, as well as fine silicious slates and purple micaceous and gneissic sandstones, the relations of which are not yet fully known. Beds of Devonian (Oriskany) age also occur, as they do both in New Brunswick and in the Gaspé peninsula, but are much less widely distributed than has been previously supposed. Finally, the slates are at a few points unconformably covered by bright red sandstones and conglomerates similar to those of the Tobique valley in New Brunswick, and the Bonaventure district of Quebec, which are referable to the Lower Carboniferous formation.

Thus the succession of events indicated by the rocks in the early history of the region under discussion would appear to be as follows. The great period of upheaval, mountain-making and metamorphism which brought Archaean time to a close, having served to determine and to some extent to limit the great St. Lawrence or Acadian basin, by lifting above the sea the ridges which still border it,—the Laurentides north of the St. Lawrence valley, ridges of similar rock along the New England coast, some of our own southern hills and similarly some of those of Nova Scotia, Cape Breton and Newfoundland—we find in the Cambrian and Cambro-Silurian periods which succeed,

that over the intervening seas were in process of accumulation a vast thickness of sedimentary beds, pebble, sand, mud and lime-beds, spread horizontally over the sea-floor, and receiving from time to time the more durable relics of the life,—Brachiopods, Crinoids, Graptolites, &c.,—with which those seas were filled. Another period of upheaval then ensued, and, through pressure brought to bear upon the same sea-floor, portions of its surface became crumpled up into folds and ridges, and its materials more or less altered in character. At the same time, along the south side of the St. Lawrence, where the foldings are most numerous and excessive, the ridges thus produced were thrust above the sea level, thus defining that great estuary upon the southern as well as on the northern side, and embracing the system of heights (the Notre Dame Mts., &c.) already described as extending through the Gaspé peninsula and forming the great divide between the St. Lawrence and the Bay Chaleur. Along the southern side of the Lower Silurian rocks thus folded, we have seen that the Upper Silurian rocks meet them unconformably, and from their northern edge, in some places not more than nine miles from the shores of the St. Lawrence, spread southward to the Bay Chaleurs and upper St. John, as well as farther, over all the northern portions of New Brunswick and Maine. From the absence, or slight representation, through most of the Gaspé peninsula, of the inferior portions of the system (Niagara group) we may infer that, for some time after the opening of the Silurian era, this district still remained too elevated to be reached by oceanic waters: but the occurrence of limestones of this age at Cape Gaspé, as well as on Anticosti, filled with marine organisms, shows that in these localities at least the great St. Lawrence Gulf was still in existence. At the same time, the occurrence of the heavy beds of conglomerate, fully 1000 feet in thickness, with the succeeding shales and sandstones, carrying Niagara fossils, on Lake Temiscouata, would seem to indicate that these waters of the Gulf spread westward, at least as far as that point, though of diminished

depth, and (to judge from the coarseness of many of the beds,) with currents of considerable power. Similar strata occurring on the Siegas River in New Brunswick, on the Beccaquimec River in the same province, and on the Aroostook River in Maine, indicate that these also were regions of similar shallow waters, with similar powerful and variable currents, and, as it would seem, subject at times to sub-marine volcanic ejections. Connected with these accumulations, and possibly in part determined by them, the floor of the gulf underwent frequent oscillations of level, and along certain tracts even more marked movements occurred, tilting (as at Burnt Point and Point aux Trembles) the heavy beds, and giving them their present steep inclination, while at others only gentle undulations were the result. Finally, over the irregular floor thus produced were deposited the later beds of the Silurian sea, mostly in the form of fine calcareous muds, now hardened into slates, but in places in the form of pure limestones (like those of Dalhousie, Mount Wissick, Square Lake, Ashland, &c.) now filled with the relics of their ancient populations. These too have since felt the force of the great earth movements which have in all ages operated so widely and so powerfully in the history of our globe, and their effects are readily witnessed in the tilted and crumpled character of many of the beds, more particularly about the Grand Falls of the St. John, but never since have they been submerged to anything like their former extent, the later beds of the Devonian and Lower Carboniferous being much more limited in this distribution, and as regards the latter at least, found in what must have been very shallow and isolated basins.

Of the still later chapters in the history of the region we have been discussing, two only can here be referred to, and these but briefly. Everywhere over the district are to be seen evidences of a former extensive glaciation in the smoothing, polishing and striation of rock surfaces, in the occurrence of travelled boulders, and in the existence of drift-dammed pond and lakes, kames, &c., some of which

are quite remarkable. The depth of some of the lakes like the Temiscouata, the Squatook and the Cabano, occupying as they do north and south depressions and with nearly flat bottoms, would seem to point to ice-movements as having been closely connected with their position and character. But what is of still greater interest is the evidence which the district everywhere affords, of a northern as well as a southern driftage at some time during the ice period, the great ridge becoming itself a centre or axis of ice distribution as it is now of the rivers which drain it. This fact is strikingly seen in the occurrence of great boulders of fossiliferous Silurian limestone strewed over the Quebec rocks at the upper end of Lake Temiscouata, and which have been derived from Mount Wissick to the south, again in the similar occurrence of such boulders at the northern end of Lake Metapedia, and finally their occurrence, in large numbers, along the St. Lawrence shore, as noticed about the Grand Métis river and Rimouski. Similar facts have elsewhere been observed by Mr. Chalmers, and are referred to in his reports on the Superficial Geology of the district.

Of the early human period, but few relics, so far as known to the writer, have yet been found in the region here considered. None were observed by us around the shores of Temiscouata Lake, but near the outlet of the First Tuladi Lake, are numerous fragments of chipped flint, together with a few sherds of pottery, indicating the former presence here of the early Pre-Historic races. So also we have failed to find any relics of this character on the St. John river above Edmunston, although below that point, and especially about Grand Falls and Aroostook Falls, they are not uncommon.

Notes on some Birds observed at Montreal.

By F. B. Caulfield.

The vicinity of a large and busy city like Montreal, with its well-travelled roads, noisy railway trains and steamboats, is not a favorable locality for studying bird life, yet, quite a number of species can be found within easy walking distance of the city; about 175 species of birds are now known to occur on the island of Montreal, and no doubt, continued research will extend the list. Our knowledge of the life history of many species is yet very limited, many interesting problems regarding their migration, nesting and distribution being yet unsolved.

I observed last summer, a remarkable instance, showing how birds of a naturally shy and retiring disposition, will, even under most adverse circumstances, cling to a place suited to their habits. Just east of the village of Côte St. Paul and close to the public road and the Lachine Canal, there is a large pond, partly surrounded by a thick fringe of water flags and other aquatic plants. During the summer months the rattle of carts and blowing of steamboat whistles is almost incessant upon one side, while on the other a gun club has its quarters, and on Saturdays at least, keeps up a constant fire, the shot frequently striking the water with a sharp splash.

Passing by this pond on the 24th of last May, I was surprised to see several red-winged black birds, *Agelaius phœniceus*, rise from the reeds and circle around, uttering cries of alarm. This habit of flying up from the cover when alarmed, probably prevented their raising a brood, as on visiting the place a little later in the season, none were observed. I was pleased to find here a bird I had not previously met with, the Long-billed marsh wren, *Cistothorus palustris*, numbers of which were singing in the reeds, their harsh, guttural notes making the place quite lively. Owing to their habit of hiding in the reeds, just above the surface of the water, only showing themselves for an instant, I failed to secure specimens, which I particularly wished to

do, as the species is not represented in our collections. Indeed I have not seen it on any Montreal list, although I believe it has been observed on Nun's Island by Mr. Dunlop. Quite a number of rails were heard and seen in the pond, one of which was secured and proved to be the Virginia Rail, *Rallus Virginianus.* As both these species frequented the pond until the summer was well advanced, they no doubt, reared at least one brood, their hiding habits enabling them to escape the dangers by which they were surrounded, while the blackbirds, not availing themselves of this protection, were, early in the season, either killed or driven away.

The important question of the food habits of birds, and their influence upon the insect world, has not yet received the attention which it deserves; and with the exception of the few who have investigated the matter, the general opinion is, I think, that birds are, with very few exceptions, highly beneficial, and that insects are, with equally few exceptions, exceedingly injurious, or in other words, that if the birds did not eat the insects and thus reduce their numbers, they would multiply to such an extent as to entirely destroy all vegetation.

While freely admitting the charm which the beauty and melody of the birds gives to the summer, and fully endorsing the laws enacted for their protection, I incline to the opinion that their practical value has been over-estimated.

It is obvious to any one who has given the subject a little attention that there are some kinds of insects that birds do not care to eat, for example, the hairy caterpillars, prominent amongst which are the Tent caterpillars, *Clisiocampa Americana,* and *C. Silvatica.* These troublesome insects are more or less common every summer, and during some years become excessively numerous. When first hatched they conceal themselves beneath a web, but when about half-grown, scatter over the trees, and may be seen resting in groups on the trunks and larger limbs. I have seen thousands thus exposed, but have never seen a bird eat one, or indeed notice them in any way. I have, however, on two

occasions observed a large species of ground beetle, *Calosoma frigidum*, killing them, seizing a caterpillar in its powerful jaws and shaking it just as a terrier does a rat. Professor Saunders, in his Presidential address to the Entomological Society of Ontario, for 1880, speaking on this subject, says: "When the cut worms were so common with us, this spring, that any bird, with very little effort, might have its fill of them, the contents of a number of stomachs were examined, especially those of the robin, and not a single specimen of this larvæ was found in any of them. It has been urged that some birds devour the larvæ of the plum curculio, by picking them out of the fallen fruit, but I have failed to find any confirmation of this statement, indeed never found a curculio larvæ in the stomach of any bird, excepting once in that of a robin, who had evidently swallowed it by accident when bolting a whole cherry.

As for the robin having any claims upon the sympathies of man for the good he does, I fear that but a very slight case can be made out in his favour. Of fruit he is a thief of the very worst kind, stealing early and late, from the time of strawberries until the last grapes are gathered, not content to eat entirely the fruit he attacks, but biting a piece out here and there from the finest specimens, and thus destroying a far greater quantity than would suffice to fill him to his utmost capacity. At the time of writing, flocks of the most pertinacious specimens are destroying the best of my grapes, while alongside is a patch of cabbages almost eaten up with the larvæ of the cabbage butterfly, nice, fat, smooth grubs, easily swallowed, but no such thing will Mr. Robin look at as long as good fruit can be had."

I have myself, during the past year and up to the present, so far as my opportunities would permit, examined the stomachs of birds, with the following results:—

1888.

May 14th—Baltimore Oriole. *Icterus galbula*. Ground beetles belonging to the genera *Platynus* and *Pterostichus*.

These are predacious insects, and are classed as beneficial.

Of three summer warblers obtained on the same date, the stomach of one contained specimens of *Syneta triplax*, a leaf-eating beetle, and although not sufficiently numerous to do much harm, is certainly to be classed as injurious. The second had been eating a species of *Paria*, also injurious. The third contained some triplax, same as first, also some of a species of *Aphodius*, a beetle living in cattle droppings, and may be set down as neutral.

May 19th—Scarlet Tanager, *Piranga erythromelas.* May beetle, *Lachnosterna fusca.*

This injurious insect was very abundant last season, many birds eating it.

May 21st—Baltimore Oriole, *Icterus galbula.* Predacious ground beetles, belonging to *Platynus* and *Pterostichus.*

May 22nd—Purple Grackle. *Quiscalus aeneus. Platynus, Pterostichus*, one Elater and *Lachnosterna fusca*, four species.

Two injurious, and two beneficial.

May 24th—Baltimore oriole, *Icterus galbula. Lachnosterna fusca.*

A second specimen had eaten an hymenopterous insect, but it was too much broken to be determined.

Red-eyed Fly-catcher. *Verio olivaceus.* Some species of bug, *Hemiptera.* Blue bird. *Sialis Sialis. Lachnosterna fusca*, swallowed entire, wing-cases, legs and all, an immense mouthful for a small bird.

Bobolink, *Dolichonyx orizivorus.* Wheat and a few small *Carabidae.*

May 25th—Cat-bird. *Galeoscoptes Carolinensis.* May beetle, *Lachnosterna fusca.*

May 28th—Purple Grackle. *Quiscalus aeneus.* May beetle, *Lachnosterna fusca.*

June 9th—Tyrant Fly-catcher. *Tyrannus Tyrannus. Aphodius* fosser. Ichneumon, too much broken for determination.

Some blue jays, *Cyanocitta cristata*, obtained in the fall, had been feeding on beech-mast, one specimen having swallowed no less than ten of these sharp-pointed nuts.

1889.

March 9th—Blue bird, *Sialis Sialis. Carabidæ,* and one Lepidopterous larvæ.

March 16th—Blue bird. *Sialis Sialis.* Sumach seed, an Orthopteron, *Tetigidea polymorpha,* and one *Lepidopterous* larvæ.

April 5th—White rumped Shrike. *Lanius ludovicianus excubitorides.* Caribidæ.

April 6th—Northern Shrike. *Lanius borealis.* Carabidæ.

April 19th—Cow-bunting. *Molothrus ater.* Dung beetles. *Aphodius.* Varied wood-pecker. *Sphyrapicus varius.* Small carabidæ.
Golden-winged wood-pecker. *Colaptes auratus, Ants. Formica.*

These notes, although by no means as full as I would wish, are sufficient, I think, to show that the birds did not confine themselves to any particular kind of insect, but took what they happened to meet with, and would, therefore, be as likely to destroy the useful species as those that are injurious, and this objection, I think, applies to all animals that eat insects, such as toads and frogs, and many of the smaller mammals. All of these take the good and bad together, and can only be useful in so far as they may be a check on the whole race of insects.

The true check upon injurious insects is the host of parasitic species with which the larvæ of nearly all butterflies and moths and many other noxious species are infested.

Let us take two well-known species as illustrations:

The Cabbage Butterfly, *Pieris Rapae*, was by some means brought to this country from Europe some twenty-five or thirty years ago, and as its principle food plant was plentiful, and the summer long and warm, it soon became excessively abundant.. Of late years, however, its numbers have been greatly reduced by a small hymenopterous insect, *Pteromalus puparum.* which, piercing the caterpillar with its ovipositor, deposits a number of eggs in its body. The caterpillar thus attacked, continues to feed, and in due time changes to a chrysalis, but never reaches the perfect or butterfly state. The parasites now finish their work, and transforming within the chrysalis, cut their way out, to destroy in their turn another brood of caterpillars.

The May beetle is another instance. The larva of this insect passes its preparatory stages in the earth where it feeds on the roots of grasses and other plants, never appearing above ground until it emerges as a beetle, but even this concealment does not save it from its enemy, a large black ichneumon fly, *Typhia inorata*, which, by some wonderful instinct finds it and deposits an egg in it, after which its death is only a question of time. The thoroughness of the work done by the parasitic insects is no doubt largely owing to the fact that as a rule they restrict their attacks to a single species, or to species belonging to the same genus. Moreover, the life of the perfect insect is generally brief and almost entirely occupied in providing for the continuance of the species, hence these parasitic insects are constantly occupied in searching for the particular kind of larvæ to which their instinct teaches them to commit their eggs. The bird might eat the caterpillar if it came in its way, the parasite must find and destroy it, or fail to accomplish the chief end of its existence. But the question may be asked, how is it that with this army of parasitic insects to help us, we are ever troubled by injurious species? Well, Nature's plan is not to exterminate any species, but to keep all within proper bounds, we, however, are continually violating her laws, covering acres of ground with wheat, cotton, or some other crop to the entire exclusion of all

others. Nature, protesting against this, multiplies the insects that feed upon it, and when these in their turn become too numerous, the parasitic species come. We cannot however always afford to wait until these get the mastery, as their work though sure, is often slow, and so we have to battle with the bugs for our potatoes, and with paris green murder both friend and foe.

In a circular on the protection of North American birds, issued by the American Ornithologists' Union, the following statement is made: "With the decrease of birds at any point, is noted an increase of insects, especially of kinds injurious to agriculture. The relation of birds to agriculture has been studied as yet but imperfectly, but results could be cited which go far to substantiate the above statement of their general utility."

I have seen similar statements in other publications, and also, some to the effect that when the birds were again allowed to increase, the insects decreased in a corresponding degree. These views may be perfectly correct, and are certainly very generally held. I have, however, so far failed to find anything showing that they are the result of careful investigation, and it is worthy of notice in this connection, that many kinds of insects do at times suddenly increase to an enormous extent, and just as quickly die off again, apart altogether from any unusual increase or decrease in the numbers of the birds. In 1884, the clover fields in the Ottawa district were seriously injured by a caterpillar which suddenly appeared in immense numbers, it proved to be the larvæ of *Agrotis fenica*, a moth which had previously been quite a rarity, and probably unknown, except to entomologists. When almost full-grown they were attacked by a fungoid disease which quickly destroyed them, but very few producing the moth, nor have they since occurred in such unusual numbers.

In 1881, the pasture fields of Northern New York were attacked by an immense army of caterpillars, entire fields being laid waste in ten or twelve days, and in some places they were so numerous that they could have been scooped

up by the handful. The insect, when it reached maturity, proved to be a small Grass moth, *Crambus vulgivagellus*, well known to entomologists, but had not before been observed to be at all injurious.

The same insect was quite common at Montreal during that season, but I have not since observed it.

A word in conclusion regarding the European sparrow *Passer domesticus*, introduced to America, I believe, with the expectation of its proving a check upon injurious insects. It is now conceded by almost all our leading American ornithologists that the experiment has been a failure, and the serious charge is made, that, owing to its noisy and quarrelsome habits, it drives away our native birds. Nothing that is eatable seems to come amiss to the sparrow, although its favourite food is grain of all kinds, as its robust form and strong beak indicate. In the town its principal food is the partially digested oats which it finds in the horse droppings, and this with the addition of crumbs and odd scraps is its only food during the winter months. During the summer it no doubt eats insects. These are, however, mostly the smaller dung-beetles, *Aphodii*, which it finds about cattle droppings and in the roads. It probably does eat a few caterpillars, but is just as likely to destroy a parasitized larva as a healthy specimen.

They are expert spider-catchers, hovering in front of the webs and picking them out with great dexterity, but I have no reason to think that they destroy many injurious insects. I have watched them scolding and fighting in a garden where that pest to the fruit-grower, the currant saw-fly, *Nematus ventricosus*, was to be seen in scores about the bushes, but so far as I could see, they did not take the slightest notice of them. Last summer, the conspicuous black and white caterpillars of the hickory Tussock moth, *Helesidota caryæ*, were very plentiful on Montreal mountain, but so far as I could learn were not touched by the sparrows.

Later in the season I saw a flock busily engaged in a field

of oats at Côte St. Paul, and judging by their numbers they must have done considerable damage.

Before the advent of the sparrow, the tree, or white-bellied swallow, *Tachycineta bicolor*, was common in the city, nesting in boxes put up for their benefit. Now, when they arrive in spring, they find the sparrows in possession of the boxes, and are forced to return to their original habit of nesting in holes in trees. A few years ago a large colony of cliff swallows, *Petrochelidon lunifrons*, nested beneath the eaves of a farmhouse at Côte St. Luc, but I learn that the sparrows have ejected these also, and they probably harass and annoy the yellow warblers and song sparrows, which certainly are not nearly so frequently heard within the city as in former years.

On a Species of Goniograptus from the Levis Formation, Levis, Quebec.[1]

By Henry M. Ami, M.A., F.G.S. (London and America).

In Vol. XVIII of the Annals and Magazine of Natural History, 1876, p. 128 *et seq.*, Prof. F. McCoy recorded the discovery of a "new Victorian graptolite" from "the black and red slates of the Llandeilo flags age of the Bendigo goldfield, Sandhurst, Victoria, Australia."

In this communication Prof. McCoy describes and figures this new graptolite under the name of *Didymograpsus Thureani* and concludes by proposing the genus "Goniograptus," which as he says: "might be suggested for such types as the present, in which the branches of the funicle (for which I would suggest the name stolons) are angularly bent at the points of budding into the celluliferous stems."

One year later, the same author described and figured more elaborately the same species in Decade V, of the "Geological Survey of Victoria"—Prodromus of the Palæontology of Victoria, pp. 39 and 40 where the species

[1] Published by permission of the Director of the Geological Survey of Canada.

is referred to *Graptotites* (*Didymograpsus*) *Thureani* (McCoy) with the same note and suggestion regarding the genus Goniograptus as given above.

In vol. III, section 5, of the Annals and Magazine of Natural History, Prof. Charles Lapworth recognises the validity of the genus *Goniograptus*, and refers the Victorian form to that genus, viz.: Goniograptus Thureani, McCoy; (see "the Geological distribution of the Rhabdophora" p. 80) in the table shewing the vertical range of British Rhabdophora.

The following is the description given of *Goniograptus Thureani*, by Prof. McCoy.

"Description.—Radicle conical, minute, in the middle of a short straight funicle, one and a half lines long, which bifurcates equally at each end, giving rise to four equal main branches or stolons of the complete polypidom; each branch about one inch long, bent regularly in zigzag angles of about 135° alternately giving off at intervals of about one line, on both sides from the salient angles, the regular, straight, simple stems, five or six in number on each side, and about one inch in length (more or less, as they are nearer the base or the apex), each with a row of broad acutely angular cell-denticles, seven in the space of three lines; the upper edge of each cell slightly convex, and nearly at right angles with the back; and rather longer than the undivided portion, the lower edge two-thirds uncovered by the next cell, and making an angle of about 45° with the back; from the point of one cell to the next about equal to the width from the same point to the back. The whole polypidom, of about forty stems forms a slightly quadrate circle or rounded square about two inches in diameter."

In 1886, Mr. T. C. Weston of the Canadian Geological Survey, obtained the first American example of the typical genus *Goniograptus* from the black graptolitic and linguliferous beds, in the cutting on the Intercolonial Railway, 1560 paces below the Lower Levis and Quebec Ferry, Levis, Quebec. This specimen measures about seven inches

diagonally across the flattened and expanded polypary from tip to tip, and is presented on a slab of shale nearly five inches square.

The affinity and close relationship of this Canadian *Goniograptus* to the Australian one was noticed at a glance, and as the individual was comparatively large, and presented other characters (the disc, &c.) not seen nor described in the Australian form, it was at first doubtfully referred to Prof. McCoy's species *Goniograptus Thureani* and probably new.

In 1887, Dr. Selwyn, accompanied by Messrs. Weston and Lambe of the Canadian Survey, examined numerous graptolitic and other fossiliferous localities along the south shore of the St. Lawrence, and in the collections made by the two last named gentlemen were found three additional specimens of the genus *Goniograptus* from the same locality.

All of these are evidently referable to the same genus and species, although three of them have a disc preserved which is developed around and clasps the funicle as well as the non-celluliferous branches or stolons, from the sicula or initial point of the polypary to the base of the last bifurcation of the last branch or stolon into the celluliferous stipe.

When compared with the admirable figures and description given by Prof. McCoy of its Australian congener, the American form is found to be so nearly identical and clearly co-specific that it is not deemed advisable to give it a new specific designation. The presence of a disc around the funicle and the pterate, or winged margin along both sides of the non-celluliferous branches, the large number of stipes originating at the goniate portion of the polypary are the main points of distinction, between these two geographically remote representatives of the species.

The disc and winged margin, however, are characters of generic importance, whilst the number of celluliferous branches originating at the angles of the non-celluliferous branches or extremity of the stolons are merely characters of age and size of specific value.

Both the Australian and the American specimens clearly belong to the family of the *Dichograptidæ*, which rank as the "earliest siculate graptotites" known. They belong to section "*b*" of Prof. Capworth's "Analytical table of the genera of graptotites" under "Fam. III" (see Geol. Mag. 1873, vol. X, table I), where the polypary is described as compound, and where the major extremity of the sicula gives origin to a funicle, falling under division "II," where the funicle is said to be "once divided giving origin to four main polypiferous branches which form the complete polypary." Then the genus *Goniograptus* naturally comes in this sub-division, from the manner in which its simple celluliferous branches are disposed, would fall under a new generic head between "I" and "II," or between genera Nos. 16 and 17 of the "table of genera, &c.," as the "four main polypiferous branches" "form the complete polypary" by giving off simple celluliferous branches from both margins, giving four generic heads under division II, as follows:—

I By continued dichosomous sub-divisions.

II By giving off simple branches from one margin only.

III By giving off simple branches from both margins at regular intervals.

IV By giving off compound branches from both margins.

The following are amongst the most salient characters: Dimensions are taken from the American form: Sp. No. 1—Collected by Mr. Weston in 1886 at Levis, Quebec.

Length of the *funicle:* .125 inch.

Diameter of *disc*, in the direction of the funicle: .125 inch.

Breadth of *margin of disc*, from extremity of the funicle to the outer edge or margin: .0625 inch.

Diameter of *disc*, in the direction at right angles to the funicle: .1 inch.

Disc with outer margin, concave and produced along the non-celluliferous branches or stolons, clasping them, forming a winged or alate margin which gradually diminishes in breadth from the disc proper, towards the distal extremity of the branches.

One other specimen is quite free from, or destitute of a disc—the stolons and funicle being quite naked. The *funicle* is straight and narrowly cylindrical, forked at each extremity, each fork making an angle of 135°—a right angle and a half. The *four* branches or stolons thus produced, give rise to the four zigzag or goniate arms of the polypary by a continued process of gemmation and bifurcation at regular intervals. The angles formed by the zigzag or goniate stolons become more obtuse as the distal extremity of the polypary is reached, where they form a nearly right line.

At each one of the re-entrant angles, there arises one simple celluliferous stipe of greater or less length, according to the size and age of the polypary, and according to the proximity to, or distance from the funicle. These fossiliferous stipes are disposed in alternating manner on each side of the arm, and making right angles one set with the other. In the specimen under examination, these celluliferous stipes vary from a little over *one* inch in length, at the distal extremity of the arm, to more than *three* inches near the proximal end of the same.

The *arm* itself is a little in excess of *two* inches in length, and all *four* are sub-equal, disposed regularly and symmetrically so as to form a large + shaped figure, or cross with equal (sub-equal) arms, but bearing celluliferous stipes in such a manner that they form two similar series of parallel lines occupying two vertically or diagonally opposite areas.

The angles which these celluliferous stipes make with the general direction of the arm is generally 450°, but in most of the examples the angle diminishes gradually towards the distal extremity where they make an angle of 10° only. The most perfect arm contains *twenty-one* celluliferous stipes, *ten* on one side and *eleven* on the other side of the arm. The arm, diagonally opposite, exhibits *nine* celluliferous stipes on each side: *eighteen* in all.

The third arm whose apex is twisted and somewhat crushed holds *seventeen* arms; *eight* on one side and *nine* on the other. This arm is somewhat shorter than the two preceding, whilst these first three are complete.

The fourth and last arm is broken, and exhibits only six celluliferous stipes on one side, and five on the other.

The whole polypary, about seven inches across, thus consists of *sixty-seven* celluliferous stipes, as preserved, which number would no doubt have been increased to about *eighty*, had the polypary been perfect. This number is greatly in excess of that obtained in the Australian specimens, just double.

The *thecæ* are acutely pointed and triangular, and number from 30 to 32 in the space of one inch. They are inclined at an angle of from 30° to 50° to the axis of the stipe, this variation being probably due to the mode of preservation of the specimen. Only here and there is there a short row of thecæ visible in this fine specimen, the branches having been crushed in a direction opposite to and so as to hide the cell apertures and thecæ.

As in Prof. McCoy's species, the Canadian example "forms a slightly quadrate circle or rounded square" with a diameter of nearly seven inches (about eight inches when perfect).

The presence of a *disc* or membrane clasping the sicula, funicle, &c., also extending upwards and outwards along the arms has already been noted, which feature was not preserved in the Australian specimens, which absence is evidently due to the mode of preservation and fossilization rather than to the mode of growth of the polypary.

Of the disc-bearing graptolites known to the writer, we have the following:—*Loganograptus Logani*, Hall; *L. Kjrulfi*, Brögger; *Dichograptus octobrachiatus*, Hall; *Tetragraptus Headi*, Hall; *T. alatus*, Hall; *T. crucifer*, Hall; and *Climacograptus bicornis*, Hall. This disc which acted both as support and float in the genus *Goniograptus*, as well as in the other species just enumerated, would act also as a more or less rigid membrane in keeping the celluliferous stipes from entangling—causing them to lie more or less evenly in one place. On *Climacograptus bicornis*, this use of the disc is not so evident.

When compared together, the Australian and American

representatives of the genus Goniograptus appear to be very nearly co-specific, and so identical are they, especially in their early or young stage, that it is not thought that a new specific designation is required. Should later investigations and the finding of additional material, both in Australia and Canada yield new facts, separating these widely separated forms (geographically speaking), other than those noted above—then I would suggest the varietal or specific designation *Goniograptus Selwyni* to include such forms as are included in the above description of the forms, merely adding that I have much pleasure in coupling Dr. Selwyn's name with this interesting species, from the fact that to him "must be awarded the merit of finding the first graptotite (1856) which determined the age of the gold-reef-bearing slates of Victoria." (See preface of Decade II, Pal. Victoria, 1875, p. 5).

Locality and *Formation*: Fifteen hundred and sixty paces East of Lower Levis—Quebec ferry, in the black shales of the "Tetragraptus zone" met these in the I.C.R cutting, Levis, Quebec.

Levis Formation (Cambro-Silurian or Ordovician) Collectors: Messrs. J. C. Weston and L. M. Lambe, 1886 and 1887.

Note.—The affinities of this species with the forms described by Prof. Hall as *Graptolithus Richardsoni*, and *G. ramulus* are apparent, but the compound nature of the branching celluliferous stipes readily differentiate them.

The figures (figs. 4 and 4a) of Decade I, Pal. Victoria—appear to answer well to Hall's *G. ramulus* which would evidently fall under some new generic designation whilst Prof. Hall's specific name would include both forms. The remarkable identity of species occurring at localities so widely remote, geographically speaking, is pecularly noteworthy, Dr. Selwyn having collected many species precisely identical with Canadian forms.

On Fossil Sponges from Beds of the Quebec Group of Sir William Logan, at Little Metis.[1]

By Sir J. W. Dawson, LL,D., F.R.S.

(*Abstract.*)

The discovery of these sponges was made by Dr. B. J. Harrington in 1887, and as it was obviously of much interest, was followed up by further exploration in the beds containing the fossils.

A preliminary note on the specimens was published in the "Notes on Specimens" of the Peter Redpath Museum last winter, and in the past session more thorough exploration of the beds was made by the employment of labourers to open up the more fertile layers. In this way a large amount of additional material was obtained, which has been carefully studied, and the more important specimens submitted to Dr. G. J. Hinde, the author of the British Museum Catalogue of Fossil Sponges.

The present paper gives a detailed account of the containing beds, with a map and sections. and describes the species found, which are about eleven in number, all siliceous sponges, and most of them Hexactinelid. Of these six belong to the genus *Protospongia*, one to the genus *Cyathospongia*, and five others belong to new genera which are described in the paper. There are remains indicating other species, but too imperfect for certain determination. The whole of these forms occur in two layers of black and gray shale only a few inches in thickness, in beds for the most part destitute of fossils. The specimens are all flattened and the spicules are in most cases pyritised.

The beds appear to belong to the Levis division, and contain with the sponges a brachiopod of the genus *Linnarssonia* and of fucoid, *Buthotrephis pergracilis*. In beds of sandstone associated with shales are the Graptolites of the genus *Retiolites*, probably *Rensiformis* of Hall.

[1] Read before the Royal Society of Canada, May, 1889.

The occurrence of so many species of siliceous sponges in great abundance in these beds is a new and interesting fact, and indicates that at certain times the floor of the Siluro-cambrian sea has been amply stocked with organisms of this kind, scattered spicules of which abound in layers in which specimens retaining their form have not been found.

The paper will be illustrated with photographs and figures of the species.

New Fossil Plants from the North West.

By the same Author.

This paper is a continuation of those by the same author in previous volumes of the Transactions of the Society. It relates to an interesting collection made by Mr. R. C. McConnell, B. A., of the Geological Survey of Canada, on the McKenzie River, and to specimens obtained by Mr. T. C. Weston, of the same survey on the Bow River. The species all belong to the horizon of the Upper Laramie, and serve to show the similarity of the flora of this series in the McKenzie and Bow Districts with that of other parts of the N. W. Territories, of the western parts of the United States, of the Hebrides, of Alaska, Spitzbergen and Greenland. The paper notices more especially the previous publications of Heer, on the McKenzie flora, the additional species obtained by Mr. McConnell, the geographical distribution of these species, and their Lower Eocene facies.

Notes on Erian (Devonian) Plants.

By D. P. Penhallow.

(Abstract.)

The Paper read under the above title gives a continuation of Studies on *Nematophyton*, which were presented to the Royal Society at its meeting in 1888. The author gives a few additional observations upon the principal species (*N.*

Logani), all of which confirm his previous results. More special attention is given to *N. Hicksii* and to three other plants previously described under the name of *Nematoxyten crassum*, Dn., *Nemotoxyten tenne*, Dn., and *Cellutoxyten primævum*, Dn., but all of which are here referred to the genus *Nematophyton*, thus making the whole number of probable species belonging to this genus of ancient Algæ, five.

The facts stated with reference to *N. Hicksii* add nothing to what had been observed by others. The material is wholly in fragments and the structure is represented only by siliceous coats of the cells.

Nematoxyten crassum is shown to present the same general structural features—museptate, tubular cells branching into a secondary system of intercellular filaments, as the species of *Nematophyton* previously described. *Nematophyton tenne* shows cells of a tubular character, but of very alternated size, without any well marked intercellular filaments, and in its general structure approaching more nearly to the hyphal structure of *Nematophyton laxum.*

Cellutoxyten primævum is shown to be a highly altered form of *Nematophyton*, the alteration having been effected through crystallization of silica and consequent redistribution of the highly decayed organic matter; the result being the formation of an ill-defined cellular structure. Comparison is made with well authenticated specimens of *N. Logani*, in which the same section, embracing variously altered structure, shows in one part normal cells, and in another part a false cellular tissue precisely similar to that of *N. primævum*. This latter is therefore referred, on geographical grounds as well as of probable structure, to *N. crassum*.

The Paper is illustrated by several photo-micrographs, showing the structure of the various species described.

The author also drew attention to further examinations of the laminated fossil described in his communication of last year, and also to a certain resin-like material occurring abundantly in the Gaspé Sandstones and always associated with *Nematophyton*. That the laminated fossil represents

fragments of the fronds from *Nematophyton* is a view that has received much strength from the more recent investigations, although in the absence of definite data connecting the line, must be regarded as largely hypothetical. The resin-like substance occurs in thin flakes, and is shown to be in many cases composed of a substance which presents many of the peculiarities belonging to the laminated fossil, of which it may be a more highly altered form. Attention was drawn to the desirability of a more careful examination of the beds of Gaspé Basin, with a view to collecting more representative specimens of these fossils than have yet been submitted to examination.

Annual Field Day.

Saturday morning, June 8th, 1889, at 9.15, a special train left the Dalhousie depot, containing a large number of members and friends of the Natural History Society, who that day celebrated their annual picnic at St. Eustache. Among those who were present were: Sir J. W. Dawson, president; John S. Shearer. vice-president; Prof. Penhallow, Dr. Blackader, Messrs. J. H. R. Molson, Albert Holden, J. S. Brown, C. Gibb, Graham, Dunlop, Hollis Shorey, F. B. Benjamin, J. A. Robertson, W. D. Lighthall. Mrs. Molson, Miss Dawson, Miss Hill, Mrs. Holden, Miss Mercier, Mrs Garth, Misses Morgan, Miss Van Horne and others. The visit of the society's members had evidently been looked forward to with a great deal of pleasure by the inhabitants of St. Eustache. The village was decorated with flags and bunting, and huge streamers were stretched across the streets bearing the words: "Honour to Science," "Be they welcome," "Welcome Natural History Society," etc. On the arrival of the train the depot was crowded with villagers to welcome the visitors. Mayor Paquin and J. D. Daoust, M. P., made short speeches in which they expressed their pleasure at seeing so large a number of Montrealers paying their village a visit. Waggons and carriages were waiting to convey the visitors to the different points of interest. Three classes were

arranged as follows: Botany, in charge of Prof. Penhallow; Geology, Sir J. W. Dawson; Entomology, Mr. Caulfield. Each class was driven to its respective points of interest in the suburbs of the village, where they spent several hours in search of specimens of their various hobbies.

To those whose tastes are less scientific, St. Eustache is a very attractive place, as being the site of the old struggle for autonomy in 1837. And the Natural History Society has done well in inviting those societies which are interested in the history of Canada in its various phases to accompany them in their visit to such an historic place. The ancient church still bears signs of the fight of 1837, and like a veteran warrior, still shows the scars of combat. The old cemetery which formerly lay under the shadow of the church has been done away with, but otherwise the scene of the struggle has been little altered, and the twin towers to-day look down upon the excursionists as they did upon the fierce fight that raged there half a century ago. Inside, one sees the chancel window from which Dr. Chenier and his two companions jumped when the church was burning all over, and the only chance for life was to escape from the burning building. In the churchyard outside, Dr. Chenier died, gallantly fighting to the last, and from there his body was taken to Addison's Hotel, then known as the Bull, which still stands in all its original simplicity and which was then used as a hospital for the wounded. Among the participants in the fight was Captain Marryat, who achieved greater fame as a novelist than as a soldier, and who described the battle of St. Eustache for his English readers. The old seignioral mansion then owned by Mr. Dumont, now by the De Bellefeuille family, stands in very much the same condition as when Colonel Wetherall ordered the troops to clear it of the rebels who were using it as a fortress or rifle pit. The old Globensky House also still retains a good deal of its primitive simplicity. Almost opposite the station is a very old house, the date stone on its walls showing it to have weathered the storms of a century.

Although the village has some touch of interest in its past

history, it by no means depends upon its past to-day, but it is a live, thriving place, and on the point of cleanliness is a brilliant exception to the usual run of villages in this province. The streets are lined with trees, not branches ruthlessly stuck in for a temporary *fête* but actually planted to beautify the village. The old houses supply antiquity, but the smart brick stores offer a type of modern civilization, and business has been of such a satisfactory nature that until last winter there had not been a failure for about a dozen years.

About 2 o'clock those who, as Mr. J. S. Brown put it, were fortunăte enough not to bring baskets, partook of an excellent dinner at Goulet's Hotel.

At four o'clock a meeting was held at the station, under the chairmanship of Mr. John S. Shearer. Addresses were delivered by Sir J. W. Dawson, Prof. Penhallow, and Mr. J. S. Brown.

Sir J. W. Dawson, on behalf of the "knights of the hammer," announced that the local formation is calciferous sandstone or lower silurian. It contains few fossils, the characteristic one being the Murchisonia Anna, so named by Billings, at Dr. Dawson's suggestion, because first found at our own St. Anne's, near Montreal. On the High street were two large stones of trap dyke. The inside of them having been softer than the outside, it had been so hollowed out by the weather as to form small drinking troughs. A large deposit of a variety of kaolin is found near St. Eustache. Attempts are being made to utilise it for paint, and this visit of the society to St. Eustache may result in its being used for pottery, as Dr. Dawson pronounces it "a most remarkable earth." The Botanical prize was awarded to Dr. E. Blackader, for a collection of 34 species of plants in blossom.

Votes of thanks were tendered to the Mayor, Mr. Daoust, and the villagers in general for their handsome treatment and entertainment of the visitors. In reply to this Mr. Daoust said that they needed no thanks. They were well repaid by the fact that the society had deigned to pay them

a visit, and he could only thank them and give them a hearty invitation to return. Cheers for the Village Council, the villagers and the Queen were given, and the train moved away from St. Eustache station arriving in Montreal at 6.30. The trip was a most enjoyable one and will be remembered with pleasure by those who attended.

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY.

The seventh monthly meeting of the Society was held on the evening of Monday, April 29th, at 8 o'clock, Sir J. W. Dawson in the Chair.

After reading the minutes of the previous meeting, the Rev. Dr. Campbell was appointed a delegate to the meeting of the Royal Society of Canada. The Librarian reported the usual exchanges.

The following donations were received from Mr. F. B. Caulfield :

Two Prairie Horned Larks.
One Cedar Waxwing.
Two specimens of Spotted Proteus.

From Mr. J. H. R. Molson :

Two Stalactites from Bermuda.

The thanks of the Society were tendered the donors.

Dr. B. J. Harrington presented a paper entitled, "Notes on Bibliography of Canadian Mineralogy," and "On the Number of Mining Species known to occur in Canada."

Mr. F. B. Caulfield also presented a paper entitled, "Notes on some Birds observed at Montreal."

The thanks of the Society were tendered for the above papers, which were ordered to be printed.

ANNUAL MEETING.

The annual meeting of the Society was held on Monday, May 27th, at 8 o'clock, the President, Sir J. W. Dawson, in the Chair. There were present:

Mr. J. S. Shearer, Mr. C. Gibb, Prof. Penhallow, Dr. T.

W. Mills, A. H. Holden, P. S. Ross, J. A. U. Beaudry, Dr. Campbell, J. S. Brown, E. T. Chambers, Geo. Sumner, H. T. Martin, Jas. Gardner, Dr. Stirling, Dr. Ruttan, J. H. R. Molson, J. H. Joseph, Rev. Dr. Campbell, F. B. Caulfield, Dr. J. B. Edwards.

The President's Address.

Gentlemen,—We have, I think, good reason to congratulate ourselves at the end of the session just closed that this oldest of Canadian scientific societies shows no sign of senility but rather of new life and energy. The improvements made in our building, museum and library, through the care and activity of the council, the house committee, the honorary curator, Mr. Stevenson Brown, and the librarian, Mr. Chambers, the additions to our list of members, the eminent specialists whose services were secured for the Sommerville course of lectures, the importance of that course with reference to the industrial interests of the province, the valuable papers read at our monthly meetings and published in our journal, the admirable excursions to Montebello and Abbotsford, so well planned and carried out through the kindness of our friends, Mr. Papineau and Mr. Gibb, the successful and brilliant Conversazione in which we were honored with the presence of their Excellencies Lord and Lady Stanley of Preston, are among the features of a most useful and prosperous year. They are noticed in other reports to be presented this evening, and it falls to me in this address rather to direct your attention to the more strictly scientific portions of our work, and more especially to the papers read before the Society and published in the *Record of Science*, and which may be considered, so far as they extend, as steps in advance in Canadian science. They were summarized by our delegate, the Rev. Dr. Campbell, at the recent meeting of the Royal Society in Ottawa, but they deserve a little more detailed notice here.

According to the list, kindly prepared for me by the Recording Secretary, Mr. Holden, twenty original papers

were read at our meetings and accepted for publication. Of these, the majority, thirteen in all, were on geological subjects, including mineralogy and palæontology, four were botanical and three on zoology and animal physiology. Of the geological papers, those by Dr. Harrington, Mr. Tyrrell and Mr. Adams related to rocks and minerals. By these gentlemen our attention was directed to the important and valuable coal deposits of the Northwest, embracing as we now know, all kinds of mineral fuel from anthracite to lignite, and to the curious and probably valuable deposits of gypsum recently discovered in the Northwest, as well as to the microscopic structure of some Canadian rocks. A new and interesting subject was also opened up by Dr. Harrington's notes on the Bibliography of Canadian mineralogy, which brings before us some of those pioneers of our geology, who at a time when many parts of our country were difficult of access, and when little interest was taken here in such subjects, laboriously laid the foundations of our present magnificent accumulation of geological facts. In reading the memoirs left by these men, one is struck not by the paucity of facts and the difficulty experienced in their explanation, but by the skill and penetration and unwearied industry of the men, and the magnitude and accuracy of their results in comparison with the then crude condition of geological science and the inadequacy of the means at their disposal. In the fossils of the older formations, Mr. Matthews was kind enough to lay before us, in a condensed and clear manner, some of his latest results in the study of those Cambrian rocks of New Brunswick which have yielded so many new discoveries to his skilful and painstaking researches, and I had the pleasure of bringing under your notice some new fossil plants, which seem to throw much light on ancient vegetable forms hitherto greatly disputed. A good piece of local geology relating to a little explored and interesting region, was given us in the paper of Mr. Chambers on the Lake St. John district. In more recent geology the curious modern concretions found by Rev. Prof. Kavanagh near Boucherville helped us to explain those

much larger and older cylindrical bodies of the Potsdam sandstone which have puzzled so many observers. The papers on *Balanus Hameri*, from River Beaudette, and on the varietal forms of the recent *Mya*, compared with those in the Pleistocene, were supplementary to papers formerly published on these subjects, and added to the mass of material furnished by the St. Lawrence Valley in reference to the life of the so-called "Glacial" period. The contribution of Mr. Chalmers I regard as much more important, and as illustrating by a large collection of facts the conclusion that we have to explain the Glacial phenomena of Western Canada not by an imaginary and physically impossible ice sheet, but by local glaciers, aided by floating ice. This view, which I have again and again endeavored to impress on geologists too much addicted in this matter to invoke the aid of portentous and improbable causes, has been amply vindicated by the careful observations of Mr. Chalmers in Eastern Quebec and New Brunswick. We may also place among papers relating to recent geology those of Professor Spencer on the St. Lawrence Basin and the Great Lakes, and of Mr. Drummond on the Lake Basins of the St. Lawrence. Mr. Spencer, one of our younger Canadian geologists, now transferred to an important professorship in the United States, has for many years pursued an elaborate series of observations and measurements on the former levels of the lakes, and more especially as to the evidence of unequal lifting of the lake terraces depending on the warping of the earth's crust in the elevation of the continent. These observations when complete will form very important contributions to the Physical geography as well as geology of North America. Our botanical papers we owe to Prof. Penhallow, Prof. Goodwin and Mr. Ami. That on ringed trees was a curious contribution to vegetable physiology. Another directed our attention to the edible qualities of a fruit not hitherto regarded with much favor, that of *Shepherdia Canadensis*, and the local flora of Montebello was connected with the excursions of the Society to that place, on the kind invitation of Mr. Papineau, and was an illustra-

tion of the varied assemblage of plants which characterizes the junction of the Laurentian and Palæozoic rocks, and the diverse kinds of soil and station which these afford. Our Zoological papers were few, but not unimportant. Dr. Wesley Mills gave us some interesting contributions from the physiological work which he has so successfully pursued, and the observations of Mr. Caulfield on birds observed at Montreal were of much interest, raising among other things the questions of the relations of the imported sparrow to our native birds, the services and misdeeds of the former, and the manner in which it is accommodating itself to the peculiar conditions of our climate. These questions were merely opened up by Mr. Caulfield, and I hope will be followed farther by him in the same earnest and observant manner. One fact to be noted in regard to the services of insectivorous birds, and which is often overlooked, is that the multiplication of certain species of insects which these birds do not relish or cannot easily destroy, is no proof that they do not deliver us from others which, but for their agency, would become equally abundant. Farther, we cannot expect birds to annihilate the species on which they feed, but only to keep down their numbers. The amount of original work implied in these papers may not be large, in comparison with that done by stronger societies abroad; but in so far as it goes, it is so much gained to science, so much of valuable fact and inference obtained and preserved for future use, and marking a perceptible advance in knowledge. On this we may well congratulate ourselves, and take courage for the future, and I would again say here that our friends should remember that any facts or specimens throwing any new light on the geology or natural history of this country will not be despised by us, but are always welcome at our meetings. Every genuine and accurately observed fact in natural history is a gain, often a much greater gain than that which results from mere speculation and generalization, however brilliant.

I have now, in resigning the position of president with which this Society has honored me for a number of times, to

ask that I may be permitted to see it transferred to younger and abler hands. I have arrived at a time of life when it has become necessary to husband my remaining powers, and there are so many unfinished departments of work in connection with the University and with the scientific studies which are dear to me, that I feel it necessary to retire from as many engagements as possible. I also feel that there is much to be done by your president for which I have not the time or strength, and that a new impulse might be given to our work by the selection of a younger man. I shall for my part be ready as formerly to contribute to the Society such results of my studies as may seem likely to be useful and acceptable, and shall be happy to do anything that I can as a private member to promote the interests of the Society. It will be a pleasure to me to lay down my official connection with it at a time when its condition and prospects are so good as at present, and when I hope it has entered on a new career of increasing prosperity and usefulness.

The following reports of Committees were submitted:

Report of the Council.

The Council beg to submit the following report:—

The session which this meeting brings to a close, has been one of much interest in every department.

There have been seven meetings of the Society, and thirteen of the Council, five of which were special, in connection with the Autumn "Field Day," and the "Conversazione."

Thirty-five ordinary and three associate members, have been added to the Society during the year, as against twelve last year.

The Library has received a good deal of attention from Mr. Chambers, the Chairman, and the other members of the Committee, but considerable work has yet to be done by the Committee to be appointed for the coming year.

The Society's building is now in better condition than for many years past. The Council authorized the Hon. Curator,

and the Chairman of the House Committee, to make some changes in the "Aquarium Room," re-arrange to some extent the "Museum," and generally to improve the interior of the building. They had to find the means with which to do this, and have to thank members of the Society, as well as a number of citizens, who kindly contributed to this end, but the work is far from being completed, they recommend their successors in office to follow up what they have begun until the "Museum," and the entire building, be put into first class condition.

We have received during the year for rent of Hall, Library, and Committee Rooms, about $1,200.00, being a large increase over any previous year.

In the Superintendent's report to the Chairman of the House Committee, there is the following memo.:—

Received from Visitors to "Museum,"	1887-88........	$27.00
Do " " " "	1888-89........	76.90
	Increase.....................	$49.90

The yearly grant from the Provincial Government, Quebec, of $400.00 was duly received and handed to the treasurer, Mr. P. S. Ross.

The Editing Committee have done their work nobly. The thanks of the Society, are due and tendered to Prof. Penhallow, Dr. Harrington, and the other members.

The Annual "Field Day" was held at Montebello, on the grounds of the Hon. Mr. Papineau. The excursionists left Dalhousie Square Station punctually at 9 a.m. The morning was cloudy and looked like rain, but turned out fine. The train reached Montebello before noon, and was met at the station by a few scientists from Ottawa, amongst them were, Mr. J. F. Whiteaves, Mr. M. Ami, and others. The party proceeded at once to the residence of Mr. Papineau, and were received, and welcomed by him in a few well-chosen words. They were then conducted to his "Museum," full of objects of interest, which were appreciated and admired by all. The excursionists here divided into sections, bent on Geological, Botanical, and Entomological work, while quite a number enjoyed the beauties surrounding the residence of our host.

At 4.30 p.m., the party, by previous arrangement, met in front of the house, when Mr. J. H. R. Molson, proposed a hearty vote of thanks to Mr. Papineau, seconded by Prof. Bovey, to which Mr. Papineau responded, when cheers were given, and the excursionists said good-bye to their kind host, and his lovely grounds.

On arrival at the station, the first business was to decide who were the prize winners. Dr. Harrington, Mr. Whiteaves, and Mr. M. Ami examined the various collections, and named the successful workers in the three departments for named and unnamed specimens. Then bidding "good-bye" to their Ottawa friends, the party boarded the train for home, and found Mr. Burgess in charge of a car decorated with flags and evergreens, when an elegant lunch was provided for the excursionists with the usual kind forethought, and hospitality of the Canadian Pacific Railway. A rapid run brought the party to Dalhousie Square Station at 7 p.m. On the platform a vote of thanks and three rousing cheers were given to the officers of the C. P. R. for their kindness. Home was next in order, and the excursionists separated, all delighted with the day's outing.

Mr. Chas. Gibb, of Abbotsford, tendered an invitation to the Society, for an Autumn "Field Day," which was accepted for September 29th. Some one hundred and twenty (120) excursionists proceeded to Abbotsford by the Canadian Pacific Railway to enjoy Mr. Gibb's hospitality at his lovely residence, and all found a hearty welcome, a splendid lunch was prepared to which the party did ample justice. The large, and beautiful orchards were open for inspection, and enjoyment of the whole party. The trees were loaded with apples of every description, amongst them a variety of Russian apples. Mr. Gibb has also a plantation of ornamental and other trees from amongst which he is endeavouring to find out those best adapted to our Canadian climate. The excursionists divided up into parties, the most numerous led by Sir J. W. Dawson, went to the top of Yamaska Mountain, where a splendid view of the country (although a snow storm intervened) was obtained. Sir J. W. Dawson

delivered an admirable address on the mountain top, upon the Geological features of the vicinity. The Botanical party worked upon the mountain, under the direction of Professor Penhallow. The collections made were principally Geological, the Botanical specimens were not so numerous.

The excursionists met at the house at 3.30 p.m., when addresses were delivered by Sir Wm. Dawson, and Prof. Penhallow. A hearty vote of thanks was tendered to our host for this, another proof of his many kind acts to the "Natural History Society." The party left for the train when Mr. Gibb, with his kind thoughtfulness, had baskets full of his lovely apples waiting them. Good-bye was said and cheers given for Mr. Gibb, and the party started for the city, after a day of pleasure and profit.

The Society decided to hold a "Conversazione" on February the 28th, and invite Lord Stanley (the Patron of the Society) and Lady Stanley to be present. Committees were appointed for each department, and through our President, Sir Wm. Dawson, the Governor General Lord Stanley and Lady Stanley accepted the invitation. The excellent work done by the several committees, and the pressence of Lord and Lady Stanley made the "Conversazione" a complete success. The thanks of the Society are due and hereby tendered to the "Microscopic Society," to the ladies who kindly assisted in decorating the "Museum," and also to the following gentlemen, Mr. J. Stevenson Brown, Prof. Penhallow, Dr. Harrington, Dr. Girdwood, A. Holden, Geo. Sumner, Horace T. Martin, Dr. McConnel, and to Mr. Armstrong for his splendid exhibits from the North West.

The Sommerville course of lectures, six in number, delivered last winter were of a high order, and attracted good audiences. The subjects and names of the lecturers are as follows:—

Feb. 21st—"Agricultural Education." By Sir J. W. Dawson, C.M.G., F.R.S.

March 7th—"Forestry for Canada." By Hon. H. G. Joly De Lotbiniere.

March 14th—"Our Fruits, Past and Present." By CHARLES GIBB, Esq., B.A.

March 21st—"Economic Entomology as a Branch of Agriculture." By JAMES FLETCHER, Esq., F.R.S.C., Dominion Entomologist.

March 28th—"The Food of Plants." By Prof. D. P. PENHALLOW, B.Sc., F.R.S.C.

April 4th—"Sugar-producing Plants." By W T SKAIFE, B.A. Sc.

The Society beg to tender to these gentlemen their thanks for their kindness in coming forward so generously and assisting by delivering those interesting and instructive lectures.

An important feature during the year, was a resolution passed by the Council, to open the "Museum" of the Society, free to the colleges and schools of the city. A circular was issued placing the "Museum" at their disposal every Saturday, which has been duly acknowledged. A large number with their teachers have already taken advantage of the offer.

During the year 1868, this Society required money for a special purpose. A number of citizens came forward and subscribed very liberally, fully supplying the needed funds. Such an example would be well worth imitating at the present time, and would materially assist the Society in the good work it is doing for the Province of Quebec, and we might say for the whole Dominion. About $10,000 is required to put the Sommerville Course of Lectures upon a proper educational basis, and for enabling our scientific workers to prosecute their work thoroughly. This cannot possibly be done without adequate means, and it is to be hoped our citizens will come forward and subscribe liberally to this end.

We cannot close this report without mentioning the careful attention given to the building and its contents by the Superintendent, and the assistance he has rendered to the officers on all occasions.

The "Field Day," this year will be held at St. Eustache, on the 8th of June.

Respectfully submitted,

JOHN S. SHEARER.

CURATOR'S REPORT, 1888–89.

During the past year numerous changes have been made in the Museum, but it must be understood that, in this report, reference only is made to what has been accomplished since the present Curator took office, in October last.

Owing to the insufficiency of light in the Aquarium Room since the building of the Victoria Rifles' Armoury, it was deemed advisable to remove the specimens and convert it into a neat and comfortable Hall to be rented for evening meetings, or to be used by the Society when required.

The fish case, which originally stood at the north end of this room, has been removed to the upper gallery, and its contents have been carefully dusted, cleaned and re-arranged, whilst the long case which stood at the east side has been taken away completely, part of the specimens have been placed in other parts of the Museum, and the balance has been carefully put away until such time as new cases can be provided.

The cabinet of reptiles which also stood in this room, but which had fallen into a state verging upon ruin, has been repaired, and now stands upon a suitable table at the head of the gallery stair.

A considerable amount of time was occupied in re-arranging this cabinet; the specimens, originally preserved in spirits and which had become dried up and useless, were culled out; the bottles and jars containing those yet good have been all washed and the stuffed specimens cleansed with turpentine and varnished where necessary.

The alligator, crocodile and whale have been re-varnished; a new stand has been provided for the old cannon, and the cases in the gallery have all been painted to correspond with those in other parts of the Museum.

Special reference must be made to the gallery of the Museum, which through neglect had been allowed to fall into a deplorable state of dilapidation. Many of the specimens nailed upon the walls were inaccurately named or described, and the majority were without labels, others

again had been seriously damaged through being attached to the walls by large and unsightly nails which, in many cases, had been driven right through the objects. A complete re-organization of this department was found necessary. The specimens were accordingly carefully removed from the walls and laid aside, while the slats upon which they should have hung were repaired, painted and varnished. Small brass hooks have been placed at intervals along these slats and the specimens attached thereto by means of fine copper wire. The specimens were first thoroughly cleaned, then classified according to locality, and afterwards hung in their respective groups. Fresh labels have been written in bold, clear characters and affixed to the various objects, so that each tells its own short history in few words. The work of re-arranging this department has been both irksome and laborious, and occupied very considerable time. In this connection your Curator wishes to testify to the very great assistance rendered him by Mr. Shearer, Mr. Holden, and Mr. Martin who, at considerable personal sacrifice, devoted between twenty and thirty evenings to this work during the winter, working on several occasions till after midnight. Indeed, had it not been for the untiring energy of these gentlemen much that has been accomplished would remain undone, and the thanks of this Society is certainly due to them for their zeal in these matters.

A large collection of war implements, mats, and other objects of interest from Samoa, presented to the Society some time since, but which had never been unpacked, are now labeled and placed in appropriate positions.

There has been a large increase of visitors to the Museum this year as compared with last, as the following figures show: last year there were admitted 451; this year, 1192.

The expenditure in connection with the various alterations, improvements and repairs referred to in this report has been met from a special fund provided for the purpose by a few friends, and this is probably the first year in the history of the Society in which the Treasurer has not been

called upon to foot the Curator's bills. This fund, however, is now about exhausted, and there remains much work yet to be done. Surely it will not be discounting the future unduly to ask those who may be in charge of these matters in the ensuing year to continue the work already begun, in the hope that ere long some public-spirited citizen will come to their assistance in such a way as to enable them to make the Museum a credit to the Society as well as an honor to the city.

This report would be incomplete did it not specially refer to the assistance rendered by the Superintendent in re-arranging the specimens and in keeping the Museum clean and free from dust, to the civility and attention shown to visitors, and the general interest he has taken in matters connected with the Museum.

The following list comprises the donations to the Museum during the year:—

Coluber eximus (Milk Snake).
Balanus hameri, several specimens.
Astrophyton Agassizzii (Sea Basket).
Tamais striatus. Albino variety. (White Chipmunk.)
Several specimens of Coleoptera, Lepidoptera and Ambulatoria.
Two Stone Gouges and a specimen of Fossil Wood.
Woodland Caribou, mounted complete.
Stalactites, 2 specimens.
Octocoris alpestris praticola (Prairie Horned Larks), 2 specimens.
Ampelis cedrorum (Cedar Waxwing).
Manitoba Grouse, 2 specimens.
Menobranchus maculatus (Spotted Proteus).

Respectfully submitted,
J. Stevenson Brown, *Hon. Curator.*

To the President and Council, Natural History Society of Montreal:

Gentlemen,—In submitting the Annual Report of the Editing Committee, it is gratifying to be able to state that the past year has been one of general progress in all the work assigned to this Committee. The number of exchanges has steadily increased, and more than the usual number of requests for exchange have been made. As pointed out in previous reports, the Record of Science is the most impor-

tant medium through which the work of this Society can be extended and made known, and it is felt that every effort should be made, not only to maintain the RECORD, but to promote its increased efficiency. With this end in view, we would submit the following recommendations:

There should be appointed an Editor who shall have direct charge of and be responsible for the proper publication of the RECORD, and four associate editors who will assist him in the proper selection of material and otherwise advise him.

The sum of one hundred dollars should be appropriated to the employment of an assistant, who shall read the proofs and otherwise act under the supervision of the Editor.

Provision should be made for increased illustration of articles where such is needed, and in the near future an increase in the size of the journal may be found desirable.

We would also recommend that in future all books, periodical publications and works received in exchange, be acknowledged by the Librarian, to whom such duty properly belongs.

Respectfully submitted,
On behalf of the Editing Committee,
D. P. PENHALLOW, *Chairman.*

To the President and Council of the Natural History Society:

The Library Committee have to report that the following works have been presented to the Library during the past year, for which in the name of the Society, they desire to thank the donors:

"The Geological History of Plants," by Sir Wm. Dawson.

"Notes on Specimens of Eozoon Canadense," by Sir Wm. Dawson.

"On Paleozoic Rocks of the Atlantic Coast," by Sir Wm. Dawson.

"Report of the Royal Society of Canada."

"Geology of Minnesota," from the Geological and Natural History Survey of Minnesota.

"The Fishery Industries of the United States," 4 vols., from the U. S. Fishery Commissioners.

"Report of the U. S. Geological Survey."

"Embryology of Insects, and Arachnids," by J. Bruce, from the Johns Hopkins University.

The parts (as far as published) of the "Prodomus of the Zoology of Victoria."

"Report of the Smithsonian Institution."

Besides these, many parts of the proceedings of Scientific Societies have been received in exchange for your RECORD OF SCIENCE. Several volumes of these need binding, as, in the event of any parts being lost, it is sometimes impossible to complete the set. Your Committee have not asked for any appropriation from the Council, except for the stand for the exchanges, but would suggest the necessity of a sum, $50 at least, being placed annually in the hands of the Library Committee for binding these volumes, and preventing the large accumulation of unbound works, such as is now to be found on your shelves. Much time has been spent during the year in an endeavour to arrange these, and your Committee trust that this important work may be completed in the ensuing year.

The remainder of the books in the cases on the north side of the Library have been placed and noted in the Catalogue. Those in the cases on the south side will be placed as soon as arranged and classified.

Your Committee trust that their efforts will make your valuable Library more accessible to the members, and regret that in consequence of the large number of unbound parts that have had to be looked over, the work of arranging and placing them could not be completed within the past year.

Respectfully submitted,

On behalf of the Library Committee,

E. T. CHAMBERS, *Chairman.*

TREASURER'S REPORT.

STATEMENT NATURAL HISTORY SOCIETY.

Receipts.

Rents	$1,008 50
Subscriptions	569 00
Field Day Excursion, "Conversazione"..	129 27
Special Donations	109 85
Government Grant	400 00
Entrance Fees	76 90
	$2,293 52

Disbursements.

Balance due Treasurer	$ 5 30	
Salaries and Commissions	392 76	
Soil Temperatures	67 70	
Sundry Expenses, Caretaker, &c	469 22	
Fuel and Light	376 55	
Repairs Buildings—Museum, &c	160 07	
Taxes	144 20	
"Record of Science"	293 93	
Lectures	115 53	
House Furnishing	28 50	
Interest	12 96	
House Improvements	210 00	
Balance on hand	16 80	
		$2,293 52

Balance on hand $16 80

The following officers were elected for the ensuing year:

NATURAL HISTORY SOCIETY OF MONTREAL,

Officers—Session 1889-90.

President—Sir William Dawson, LLD., F.R.S., F.R.S.C.

Vice-Presidents—B. J, Harrington, Ph. D., F.R.S.C, J. H. R. Molson, Sir Donald A. Smith, John S. Shearer, George Sumner, Edward Murphy, A. F. Gault, Rev. Robert Campbell, A.M., D. P. Penhallow, B. Sc., F.R.S.C.

Members of Council—J. A. U. Beaudry, Chairman; P. S. Ross, John W. Stirling, M.B., S. Finley, W. H. Rintoul, J. H. Joseph, Very Rev. Dean Carmichael, Rev. Canon Empson, R. F. Ruttan, B.A., M.D.

Honorary Recording Secretary—Albert Holden.

Honorary Corresponding Secretary—Horace T. Martin.

Honorary Curator—J. Stevenson Brown.

Honorary Treasurer—James Gardner.

Editing Committee—D. P. Penhallow, Chairman; B. J. Harrington, Ph. D., Dr. T. Wesley Mills, J. F. Whiteaves, G. F. Matthew.

Library Committee—J. A. U. Beaudry, C.E., F. B. Caulfield, R. W. McLachlan, Joseph Fortier.

Lecture Committee—Dr. J. B. Harrington, P. S. Ross, Rev. Robert Campbell.

House Committee—J. S. Shearer, J. Brown, A. Holden.

Membership Committee—A. Holden, P, S. Ross, Dr. Stirling, H. T. Martin, J. S. Brown, S. Finley, J. A. U. Beaudry, Geo. Sumner, Dr. Ruttan.

Superintendent—Alfred Griffin.

List of the Members of the Natural History Society of Montreal.

LIFE MEMBERS.

Burland, J. H.

Claxton, T. J.
Claxton, J. F.

Dawson, Sir J. W.
Drummond, Geo. A.

Ferrier, James

Hingston, W. H., M.D.
Hobbs, Wm.
Hunt, Dr. T. S.

Joseph, J. H.

Kay, W. F.

Latour, Major L. A. H.

Lyman, Henry

McCulloch, F.
Mitchell, James
Molson, John
Molson, J. H. R.
Molson, J. T.
Molson, J. W.

Nivin, William

Sutherland, Louis
Sumner, George

Watt, D. A. P.
Winn, J. H.

Workman, Thomas.

ORDINARY MEMBERS.

Alexander, Chas.
Allan, Andrew
Angus, William
Adams, R. C.

Baker, M. C.
Beattie, John
Bentley, D.
Bethune, Strachan
Blackader, A. D., Dr.
Brainard, T. C.
Brown, J. Stevenson
Brissette, M. H.
Buchanan, W. J.
Bemrose, Jos.
Beaudry, J. A. U., C.E.
Baker, J. C.
Barnes, Dr. F. W.
Blaiklock, F. W.
Bovey, Prof. H. T.
Bond, W. P. S.
Baylis, Rev. I. G.
Bond, E. L.
Beaudry, Dr. I. A., Inspector.
Brown, Dr. A.
Belcher, H. M.

Campbell, Kenneth
Campbell, Rev. Robert
Caufield, F. B.
Chambers, E. T.
Cheney, G.
Costigan, W. T.
Craik, Dr. Robt.
Carsley, S.
Carnagie, J.
Chapman, W. H.
Carmichael, Dean
Cassils, Chas.
Coristine, James
Carter, E. F.
Carter, G. H.

Drysdale, Wm.
Donald, J. S., Prof.
Drummond, A. T.
De Lamotte, A. W.
Devine, Thos.
Duncan, A. E.
Drake, W.
Dyer, W. A.
Dawson, Percy M.

Edwards, Dr. J. Baker

Evans, Wm. N.
Ewing, A. S.
Ewing, S. H.
Evans, F. W.
Euard, Wm.
Empson, Rev. Canon

Fortier, Jos.
Finley, S.
Fair, John
Ferrier, W. J.

Gardner, James
Garth, Charles
Girdwood, Dr.
Gibb, Charles
Godfrey, Dr. R. T.
Goode, J. B.
Greene, E. K.
Graham, Hugh
Greenshields, E. B.
Grindley, R. R.
Gault, A. F.
Greene, G. A.
Gilmour, J. Y.

Harrington, Dr. B. J.
Henshaw, F. W.
Hickson, Jos.
Hodgson, J.
Holden, Albert
Hutton, Jas.
Hope, John
Harvie, R.
Harper, John
Hart, Chas. T.
Henderson, Alex.
Holden, J. C.
Hill, J. Wentworth

Inglis, Archibald
Ives, H. R.
Jamieson, R. C.
Johnston, J. R.
Judge, Edgar
Jones, J. H.

Kennedy, W.
Kerry, John
King, Warden
Knowlton, Geo.

Linton Robt.
Lightbound, Geo.
Little, Wm.
Lockerby, A. L.
Lawrence, Capt. J.
Lyman, R. C.
Lovejoy, Dr.
Lighthall, W. D.
Lacy, D. Edgar
Lyman, H.

Mathewson, J. A.
Miller, Robt.
Mills, J. W.
Mitchell, Robt.
Morrice, D.
Mills, T. Westley
Murphy, Hon. Ed.
Mussen, Thos.
Martin, Horace
Minto, William
Morgan, James, Jr.
Murphy, John

McCallum, Dr.
McDonald, W. C.
McEachran, Dr.
McKenzie, Hector
McLennan, Hugh
McLachlan, R. W.
McGowan, A.
McShane, James, M.P.P. Hon.
McGregor, James

Nicholls Mr. Bertie
Notman, William

Ostell, John

Penhallow, Prof. D. P.
Prowse, G. R.
Patton, Thos.
Phillips, C. D. J.
Phelps, Geo.
Paton, Hugh
Phillips, H.

Ryan, Hon. Thos.
Rintoul, W. H.
Robertson, And'w, Chair'n H C.
Ross, Dr. Geo.
Ross, P. S.
Radford, Ed., P.O. Box 1487.
Roddick, Dr. T.
Robertson, J. A.
Reford, Robt.
Robertson, Alex.
Ruttan, Dr.

Stirling, John
Shearer, James.
Shorey, H.
Shearer, John S.
Silvermann, S.
Smith, Sir D. A.
Smyth, W. J.
Stevenson, R. R.
Slessor, James
Smith, Dr. J. Lapthorn.
Scott, Gilbert
Smith, J. Murray
Stirling, Dr.
Smith, Master H. M., Assem
Smith, Miss Annie L. "
Small, Ed.
Stephenson, W. A.
Skelton, Leslie J.

Thomas, F. W.
Thomas, H. W.
Trimble, Thos.

Van Horne, W. C.
Vasey, Prof. T. E.

Wanless, Dr. John
Williamson, James
White, R.
Wood, C. S.
Williamson, Rev. J.

CORRESPONDING MEMBERS.

Hubbard, Prof. O. P., *Hanover, N.H.*

Jowitt, A. A., *Sheffield.*

Laberge, Chas., *St. Johns, P.Q.*
Langevin, J., *Rimouski, P.Q.*
Latour, Dr. C. H. *Boucherville, P.Q.*
Lavalle, Rev. M., *St Vincent de Paul, P.Q*
Leaycroft, J. W., *Quebec, P.Q.*
Lee, Dr. J. C., *London, P.O.*

Macoun, J., *Ottawa, P.O.*
Marsh, Prof. J. W., *Forest Grove, Oregon.*
Matthew, G. F., *St John, N.B.*
McCantee, Dr. T. B., *Boston.*
Mackay, A. H., *Pictou, N.S.*
McDougall, P. L., *Toronto, P.O.*
McFarlane, Thomas, *Actonville, P.Q.*
McFarlane, Thomas, *Ottawa. P.O.*

Nelson, Dr. Wolfred.
Newcombe, Dr. W., *Troy, N.Y.*
Niles, B. F., *Washington, D.C.*

Osler, Dr., *University of Pennsylvania, Philadelphia. Pa.*

Packard, A. S., *Providence, R,I.*
Pilote, Rev. F., *St. Anne de la Pocatière, P.Q.*

Robinson, Rev. P., *Abbotsford, P.Q.*
Rose, H., *Granby, P.Q.*

Salisbury, Dr. J. W., 9 *West 29th Street, New York City.*
Saunders, W., *London, P.O.*
Sicotte, Judge, *St Hyacinthe, P.Q.*
Spence. J., *Pointe Claire, P.Q.*

Taché, J. C., *Quebec, P.Q.*
Thieleke, H., *Quebec, P.Q.*
Turcot, Dr. M., *St Hyacinthe, P.Q.*

Westwood, Prof. J. O., *Oxford, England.*
Wilson, Prof. D., *Toronto, P.O.*
Winslow, W. C., Ph.D., LL.D., D.C.L., 429 *Beacon St., Boston.*
Wurtele, Rev. L., *Actonville, P.Q.*

HONORARY MEMBERS.

Baldwin, Right Rev. M.S., Bishop of Huron, *P.O.*
Beaubien, Hon. Louis, *Montreal, P.Q.*

Hall, Prof. James, *Albany, N.Y.*
Hunt, Dr. T. Sterry, *Montreal, P.Q.*

Lefroy, General J. H., 82 *Queen's Gate, London, England.*

Montgomery, James, *Toronto, P.O.*

Rae, Dr.,
Rogers, Charles, *London, England.*

Selwyn, A. R. C., *Geological Survey, Ottawa, P.O.*

Whiteaves, J. F., *Geological Survey, Ottawa, P.O.*

ABSTRACT FOR THE M

Meteorological Observations, McGill College Observatory, Montreal,

DAY.	THERMOMETER.				BAROMETER.				† Mean pressure of vapour.
	Mean.	Max.	Min.	Range	*Mean.	§Max.	§Min.	§Range.	
1	31.87	36 0	26.6	9.4	29.9243	29.984	29.854	.130	.1365
2	31.28	34.8	27.6	7.2	29.7595	29.801	29.696	.105	.1543
3	33.55	38.0	28.6	9.4	29.7618	29.838	29.697	.141	.1653
4	35.62	40.1	31.7	8.4	29.8928	29.960	29.789	.171	.1303
5	32.78	40.0	27.3	12.7	30.0993	30.167	30.031	.136	.0997
6	32.68	41.0	23.8	17.2	30.3353	30.407	30.219	.188	.0978
SUNDAY....... 7	.....	47.0	24.8	22.2	....	......	......	....	....
8	40 98	48.9	31.7	17.2	30.2753	30 412	30.077	.335	.1275
9	41.52	52.0	34.3	17.7	29.8972	30.019	29.788	.231	.1647
10	37.95	44.2	30.7	13 5	29.9345	29.983	29.909	.074	.1378
11	47.40	58.0	36.2	21.8	29 7713	29.898	29 626	.272	.1693
12	41.97	49.1	32.4	16 7	29.6357	29.702	29.595	.107	.2020
13	33.65	39.3	26.8	12.5	29.8362	29.965	29 741	.224	.1175
SUNDAY........14	.....	47.1	31.8	15.3	......	......	......	....	....
15	40.50	49.1	31.7	17.4	30 4110	30 459	30.340	.119	.0950
16	47.10	59.4	34.6	24.8	30.3438	30 437	30.243	.194	.1448
17	51.93	64.2	36.5	27.7	30.1102	30.227	30.015	.212	.1693
18	53.53	66.1	38.3	27.8	30 0438	30.075	30.016	.059	.2262
19	59.40	73.6	41.3	32.3	29.9535	30.096	29 813	.283	.2802
20	62 58	69.8	57.5	12 3	29.9210	29 969	29.863	.106	.3160
SUNDAY........21	.....	67.9	32.6	35.3	....	......	.....	....	.. ..
22	33.88	40.3	28.3	12.0	30.1747	30.343	30 001	.342	.0935
23	38.02	46.2	26.6	19.6	30 3173	30.404	30.196	.208	.1318
24	51.68	63.0	36 5	26.5	29.9985	30.150	29 885	.265	.2575
25	53 53	57.0	51.9	5.1	29.9047	29.918	29 895	.023	.3603
26	51.12	55.5	45.5	10.0	29.8760	29.910	29.816	.094	.3583
27	49.92	61.0	42.7	18.3	29.5323	29.713	29.401	.312	.3323
SUNDAY........28	......	62.2	45.6	16 6	......	......	....	....	..
29	48.32	51.9	44.6	7.3	29.4657	29.570	29 377	.193	.2998
30	44.12	50.8	40.5	10.3	29 6652	29 727	29 588	.139	.2148
....Means	43.34	51.78	34.97	16.82	29.9554	......	.....	.179	.1916
15 yrs. means for & including this mo.	39.58	47.6	31.7	15.9	29.9359	......	......	.199	.1693

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N. W.	Calm.
Miles............	1353	1472	367	507	1413	2674	2134	559	
Duration in hrs..	96	113	52	48	103	130	114	49	15
Mean velocity...	14.1	13 0	7.1	10.6	13.7	20.6	18.7	11.4	

Greatest mileage in one hour was 48 on the 21st.

Greatest velocity in gusts 66 miles per hour on the 21st.

Resultant mileage, 2,790.

Resultant direction, S 72° W.

Total mileage, 10,479.

NTH OF APRIL, 1889.

anada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

‡ Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
76.7	25.2	N.E.	13.7	7 5	10	0	79	....	....	....	1
87.7	28.0	N.E.	8.0	10.0	10	10	00	....	0.1	0 01	2
86.0	29.8		7.9	6.3	10	0	16	....	Inapp.	0.00	3
62.5	24.0	S.W.	13.8	6 5	10	0	18	....	....	.	4
53 7	18.0	N.E.	12 2	1.0	5	0	96	....	....	....	5
53.0	17.5	N.	13 0	0 3	1	0	96	....	....	...	6
....	....	S. E	1.6	....	..	..	96	....	....	....	7 ....SUNDAY
50.2	23.7	E.	3.3	2.5	10	0	97	....	.. .	....	8
62 0	29.3	S.W.	16 3	3.8	10	0	44	....	....	....	9
60.3	25.3	S.W.	16.8	1.3	5	0	96	....	....	....	10
53.0	30.2	S.W.	26 0	5.3	10	0	70	....	....	...	11
74 5	34.2	N.	12 3	7.3	10	0	12	0.09	....	0.09	12
61.2	21.8	N.W.	14.8	8.2	10	0	25	....	....	....	13
...	...	N.W.	13.6	....	..		71	....	....	...	14 ....SUNDAY
39.0	16 2	N.	11 5	0.0	0	0	95	....	....	...	15
46.8	26 7	E.	6.1	0 8	2	0	92	....	....	....	16
46 2	30.2	S.	12 9	0.8	2	0	95	....	....	....	17
56.2	37 5	N.	6 8	4.0	10	0	73	....	....	...	18
55 3	42.5	S.E.	14 7	3 5	10	0	89	0.02	....	0 02	19
56 5	45 3	S.W.	25 0	4.3	10	0	74	0.04	....	0.04	20
...	....	S.W.	28.2	...	..	..	74	0.02	....	0.02	21 ....SUNDAY
48.3	16.3	W.	24 0	4.8	10	0	48	....	....	...	22
56.7	23.5	S.W.	8 2	7.2	10	0	53	....	....	....	23
67.2	40 7	S.E.	16.4	9 0	10	4	46	0 01	....	0.01	24
87.0	49 8	S.	14.3	10.0	10	10	00	0.34	....	0 34	25
95.2	49.7	N.E.	8.6	10 0	10	10	00	0.51	....	0.51	26
92.2	47 7	N.E.	20.5	9.2	10	5	30	0.10	....	0.10	27
...	....	S. E.	17.3	....	..	..	06	0.58	....	0.58	28 ....SUNDAY
88.2	45.0	S.W.	21.7	10.0	10	10	00	0.43	....	0 43	29
74.2	36.2	W.	27.4	8.8	10	3	00	Inapp.	....	0.0[illegible]	30
65.0	31 32	S 72° W.	14.55	5.48	..	..	53.0	2.14	0.1	2 15	Sums ....
67.1	....	....	....	5.90	..	..	¶52.7	1.58	6.7	2.25	15 years means for and including this month

* Barometer readings reduced to sea-level and temperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 73.6 on the 19th; the greatest cold was 23.8 on the 6th, giving a range of temperature of 49.8 degrees. Warmest day was the 20th. Coldest day was the 2nd. Highest barometer reading was 30.499 on the 7th; lowest barometer was 29.277 on the 28th, giving a rangeof 1.222 inches. Maximum relative humidity was 100 on the 25th. Minimum relative humidity was 15 on the 15th.

Rain fell on 11 days.

Snow fell on 2 days.

Rain or snow fell on 13 days.

Auroras were observed on three nights.

Solar halo on three days.

Lunar corona on two nights.

Fog on two days.

Thunderstorm on the 27th.

ABSTRACT FOR THE

Meteorological Observations, McGill College Observatory, Montreal, C

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pressure of vapour.
1	41.83	45 4	35.3	10.1	29 8348	29.919	29.757	.162	.1798
2	44.77	49.6	39.6	10.0	29.8943	29.937	29.855	.082	.2020
3	44.42	50.3	39.6	10.7	29.8447	29.869	29.816	.053	.2070
4	50.33	59.2	37.5	21.7	29.8563	29.902	29.827	.075	.2295
SUNDAY...... 5	.....	72.1	48.2	23.9	....	......	......	....	....
6	60.28	73.0	45.5	27.5	29.9842	30.042	29.946	.096	.2735
7	68.75	80.9	52.4	28.5	29.9027	29.986	29 835	.151	.3403
8	72.72	85.6	58.1	27.5	29.8472	29 866	29.811	.055	.4392
9	74 63	86.2	65.1	21.1	29.7987	29.882	29.704	.178	.4768
10	69.30	77.7	59.3	18.4	29.6282	29.697	29.567	.130	.4623
11	56.42	65 0	48.4	16.6	29.7423	29.764	29.711	.053	.2725
SUNDAY...... 12	.....	70.0	44 5	25.5	....	......	.....	....	...
13	60.90	71.8	47.9	23.9	29.8480	29.959	29.732	.227	.2787
14	57.87	64.9	52 9	12.0	29.7048	29.805	29 658	.147	.3880
15	52.92	60.2	45.3	14 9	30.0135	30.059	29.906	.153	.2690
16	47.60	52.1	42.6	9.5	30.0868	30.139	30.051	.088	.2932
17	65.33	82.8	46.5	36.3	30 0663	30 134	30 002	.132	.4840
18	77.82	88.0	70.1	17.9	30.1488	30.216	30.111	.105	.6488
SUNDAY........19	....	83.9	65.3	18.6	....	......	......	...	....
20	63.77	68.0	60.3	7.7	29.9225	29.997	29.781	.216	.5417
21	63 20	72.8	56.3	16.5	29.6150	29.723	29.531	.192	.4897
22	52.43	57.0	48.5	8.5	29.6930	29.830	29.557	.273	.3013
23	49 77	54.4	46.3	8.1	29.9165	29.966	29.868	.098	.2573
24	52.28	58.1	47.2	10.9	29.7903	29.857	29.734	.123	.2938
25	48 80	55.2	40 6	14.6	29.9612	30.009	29.868	.141	.1998
SUNDAY.... ...26	......	62.0	43.5	18.5	.. .	......	...	....	....
27	53.58	62.2	45.2	17 0	29.8702	29.997	29.691	.306	.2863
28	47.22	51 5	41.5	10 0	29 6683	29.872	29.545	.327	.2597
29	48.10	55.7	39.5	16.2	30.1127	30 169	29.955	.214	.2187
30	47.58	54.5	44 5	10 0	30.1150	30.148	30.085	.063	.2743
31	65 05	79.9	44 7	35 2	30 0003	30.063	29 959	.104	.4448
....Means	56.95	66.13	48.46	17.67	29.8839	......	......	.146	.3338
15 yrs. means for & including this mo.	54.78	63.96	45.79	18.17	29.9365	......	.....	.161	.2864

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N. W.	Calm.
Miles..	1188	539	274	591	2100	5415	1222	393	
Duration in hrs..	86	23	31	54	144	273	95	37	1
Mean velocity...	13.8	23 4	8.8	10.9	14.6	19.8	12.9	10.6	

Greatest mileage in one hour was 42 on the 28th.
Resultant mileage, 6,195.

Resultant direction, S 43° W.
Total mileage, 11,722.

ONTH OF MAY, 1889.

ada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
68 0	31.7	S.W.	24.1	9.7	10	8	24	0.01	....	0 01	1
68.3	34.8	S.W.	13.2	10.0	10	10	4	....	....	....	2
70.5	35.3	W.	11.0	8.2	10	0	10	0.03	....	0.03	3
63.2	37.8	S.W.	20.9	6.2	10	0	67	....	....	. .	4
....	....	S.W.	30.4	....	..	..	94	....	....	....	5 ....SUNDAY
54.3	42.3	S.W.	15.2	7.7	10	0	54	....	.. .	.	6
50.0	48.3	S.W.	13.0	2.8	5	2	85	....	....	....	7
54.7	54 8	S.W.	21.0	0.0	6	0	91	....	....	....	8
56.3	57.7	S.W.	26.7	2.0	4	0	87	....	....	....	9
63.8	56 5	W.	20.9	3 3	9	0	62	0.10	....	0.10	10
60.2	42.5	N.	14.4	0.2	3	0	88	....	....	....	11
....	....	N.W.	9.2	....	..	..	96	....	....	...	12 ....SUNDAY
53.8	43 0	E.	10.4	5.5	10	0	55	....	....	....	13
80.8	51.8	S.	10.2	10.0	10	10	00	0.27	....	0.27	14
67.5	42.0	W.	8.0	6.7	10	1	75	...	....	....	15
89.3	44.3	N.	15.9	10 0	10	10	00	0.23	....	0 23	16
77.7	57.5	S. E.	13.9	4.7	10	0	70	Inapp.	....	0.00	17
68 0	66.2	S.	15.7	2 5	10	0	89	....	....	....	18
....	....	S.	13.5	....	..	..	84	....	...	....	19 ....SUNDAY
91.7	61.2	S.	7.6	10.0	10	10	00	0.76	....	0.76	20
85.2	58 3	W.	7.7	10 0	10	10	33	0.91	....	0.91	21
76.5	45 2	S.W.	24.4	8.5	10	4	61	0.03	....	0.03	22
72.3	41 0	S.W.	12.0	8.5	10	1	21	....	....	....	23
75 2	44.2	S.W.	10.8	10.0	10	10	15	0.15	....	0.15	24
58.2	34.2	W.	13.7	0.5	3	0	98	0.06	....	0.06	25
....	....	S.	8.4	....	..	..	77	....	....	....	26 ....SUNDAY
70.8	43.7	S.E.	14.6	7.5	10	0	45	0.10	....	0 10	27
79 0	40.8	S.	24 3	9.7	10	8	00	0.25	....	0.25	28
65.5	36.7	S.W.	15.3	6.2	10	1	86	Inapp.	....	0.00	29
83.3	42.7	N.E.	24.8	8.3	10	1	41	0.05	....	0.05	30
73 3	55.2	S. E.	17.2	7.3	10	2	64	0.02	....	0.02	31
69.5	46.29	....	....	6.52	..	..	54.1	2.97	....	2.97	Sums ....
65.2	....	....	....	6.29	..	..	¶52.5	2.86	0.1	2.87	15 years means for and including this month

*Barometer readings reduced to sea-level and mperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 88.0 on the 18th; the great-t cold was 35.3 on the 1st, giving a range of mperature of 52.7 degrees. Warmest day was e 18th. Coldest day was the 1st. Highest baro eter reading was 30.216 on the 18th; lowest barometer was 29.531 on the 21st, giving a range of 0,685 inches. Maximum relative humidity was 98 on the 17th. Minimum relative humidity was 29 on the 7th and 12th.

Rain fell on 16 days.

Fog on two days.

Thunderstorm on the 10th and 21st.

Solar halo on the 29th.

NOTE.—The maximum temperature for the month (88.0°) is the greatest observed here in May during the 15 years over which the present series of observations extends.

ABSTRACT FOR THE

Meteorological Observations, McGill College Observatory, Montreal, (

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mean pressure of vapour
1	63 08	71.6	53·5	18.1	29 9365	39 001	29.884	.117	·4777
SUNDAY........ 2	.....	66.2	50 3	15·9	....	......	......	....	....
3	60.95	68 0	55·4	12.6	29.9167	29.973	29 841	.132	.4053
4	64 25	73 9	56.4	17 5	29 6657	29.808	29.565	.243	·4505
5	56.37	65 0	50 5	14 5	29.5152	29 534	29.489	.045	·3813
6	51.87	58 9	47·4	11.5	29 5563	29 714	29.488	.226	·3047
7	58 87	68.0	46 3	21·7	29 7322	29 823	29 658	·165	·3155
8	56 22	61.9	52.2	9 7	29 7890	29.916	29 660	.256	.3748
SUNDAY. 9	.....	57.4	50 3	7.1	.. .	......	.....	...	...
10	66 73	78.0	54 5	23.5	29.9402	29 974	29.901	·073	·5548
11	62.70	69 0	56 5	12.5	30.1097	30 089	29 956	.133	·4408
12	64.72	74.0	55·4	18.6	29.9900	30.038	30 958	.080	4153
13	65.08	74 0	58.5	15.5	29 9332	30.051	29.866	.185	·4378
14	60.62	69 0	49.6	19.4	30.1337	30.197	30.046	.151	·3300
15	65.70	73·3	60.2	13.1	29 9137	29 992	29.829	.163	·5292
SUNDAY........16	. ..	74.0	57 3	16.7	....	......	.....	....	.
17	62.23	68 9	51.1	17.8	29 8495	30.018	29.726	.292	.3087
18	56 77	66.0	45.1	20.9	30.0387	30.113	29.959	·154	·2575
19	64 58	72.8	55 4	17 4	29 7673	29·943	29.582	361	·3740
20	70 25	77 9	62 3	15 6	29.6943	29.815	29.525	290	·4715
21	68 03	76.5	61.5	15.0	29 7493	29.867	29.602	265	·5552
22	60.82	67.3	52.4	14 9	29·7243	29.898	29.624	.274	.3887
SUNDAY.. 23	......	70 0	49 6	20 4	....	......	....	....	....
24	61.15	66.9	55.1	11.8	30 3822	30 411	30 304	.107	·3487
25	63 03	72 0	52·3	19.7	30 3442	30.423	30 258	·165	·4095
26	62 92	67.0	56.3	10.7	30 0977	30.224	29.939	·285	·5178
27	70 85	77.2	63 3	13.9	30.0150	30 085	29.932	·153	·6233
28	64.07	71 9	56.7	15.2	30.1623	30 200	30.137	.063	·4743
29	70.92	79.0	59.3	19.7	30.1280	30 195	30 068	.127	.5622
SUNDAY.......30	.....	84 9	63.2	21.7	....	......	......	....	.....
....Means	62.91	70.68	54 60	16.09	29.9194	......	.....	.180	·4286
15 yrs. means for & including this mo.	64.46	73.12	55·94	17.17	29.8970	......	.....	.155	.4224

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N. W.	Calm.
Miles..	857	501	424	647	1133	3498	2538	342	
Duration in hrs..	72	37	45	63	97	218	164	23	1
Mean velocity...	11.9	13 5	9 4	10 3	11.7	16.0	15.5	14.9	

Greatest mileage in one hour was 34 on the 22nd.

Resultant mileage, 4,795.

Resultant direction, S 57 ° W.

Total mileage, 9,940.

[M]ONTH OF JUNE, 1889.

[Ca]nada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

[Mean] [r]elative [h]umidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
82 7	57.3	S.W.	12 2	9 7	10	8	07	0 33	....	....	1
....	....	W.	6.5	.		..	21	0 20	....	....	2 ....SUNDAY
76 7	53.0	S. E	6.0	8.5	10	5	00	0 08	....	...	3
76 2	55 0	S E.	6.4	8.0	10	2	63	0 07	....		4
84 5	51.5	S.W.	12.4	6.7	10	0	32	0.43	...	....	5
80.0	45 7	W.	18 5	9 0	10	5	08	0 06	....	....	6
65 0	45.8	S.W.	13 8	5 5	10	0	74	0 11	....	....	7
83.0	51.0	.....	10.7	7 7	10	0	18	0.08	....	....	8
...	...	N E.	14.6	...	..		10	0.97	....	...	9 ....SUNDAY
84 0	61 7	S.W.	13.4	7.3	10	1	32	0 07	....	...	10
77.5	55 3	S.W.	18.9	8.5	10	3	19	Inapp.	....	....	11
69 0	53 8	S.W.	20.3	3.0	9	0	83	....	....	....	12
70 7	55 0	W.	20.8	5 2	10	0	49	0 06	....	....	13
62 7	47.3	N.W.	8.7	5.7	10	0	95	....	....	...	14
83.2	60.5	S.	12.7	10.0	10	10	10	0 73	....	...	15
....	...	S.W.	8.7	....	.	..	65	0.07	....	....	16 ....SUNDAY
54.7	44 0	N.	18 0	3.8	10	0	91	....	....	....	17
57.0	40 8	N.	10 2	7.2	10	0	70	...	....	......	18
62.5	50.8	E.	16.1	6.5	10	1	55	Inapp.	....		19
64.7	57.3	S.W	24 3	5.7	10	0	79	0 04	....	....	20
81.3	61.7	S.W.	13.8	8 8	10	3	23	0.20	.	....	21
70 5	51.5	S.W.	27 6	6.0	10	1	44	0 01	....	....	22
..	....	W.	21 4	....	..	..	72	....	....	....	23 ....SUNDAY
64.2	48.7	S.W.	16 1	9 5	10	7	03	....	....	..	24
71 5	53.3	S.W.	10 6	10 0	10	10	49	....	....	....	25
89 5	59 7	S.	12.1	9.5	10	7	00	0.86	....	...	26
83 3	65 2	S. W.	13.6	6.7	10	0	64	0.36	....	....	27
79 3	57.2	N. E.	9.8	6.3	10	0	57	....	....	....	28
74 8	62 2	S.W.	8.5	3 0	9	0	80	....	....	....	29
....	....	S.W.	7.3	....	..	..	95	....	....	....	30 ....SUNDAY
73.9	53.8	....	....	7 11	.		45.5	4 73	....	..	Sums ....
68.8	....	..	...	5.67	..	..	¶55 0	3 19	....	..	15 years means for and including this month

*Barometer readings reduced to sea-level and [t]emperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 84 9 on the 30th; the great[e]st cold was 45.1 on the 18th, giving a range of [te]mperature of 39.8 degrees. Warmest day was [t]he 30th. Coldest day was the 18th. Highest baro[m]eter reading was 30.423 on the 25th; lowest barometer was 29.488 on the 6th, giving a range of 0,935 inches. Maximum relative humidity was 99 on the 1st and 26th. Minimum relative humidity was 27 on the 17th.

Rain fell on 20 days.

Fog on 1 day.

Thunderstorm on the 4th, 9th and 13th.

NOTE.—The rainfall is nearly equal to the greatest in June (4.82 in 1879) during the past 15 years. The depth of rain in June 1882, was the same as this month. The number of days rain in June 1879, was 21, and in June 1882 rain fell on 2[illegible] days. The average number of wet days for June is 1[illegible].

NOTICES.

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THE

CANADIAN RECORD

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SUGAR PRODUCING PLANTS.[1]

By WILFRID SKAIFE, B.A. Sc.

I have to speak of the manufacture of sugar and the plants from which it is extracted. Of all the chemical industries properly so called, this is probably the oldest, and it is now the greatest, both as regards the capital involved and the general importance to all classes of mankind. It is said that the march of civilisation in a country is marked by an increase in the consumption of sugar and of soap, and this is certainly supported by present statistics. The world seems to have got on very well with little or no sugar until the 16th century of our era, when the introduction of tea and coffee into Europe increased the demand an hundred-fold and more, and refineries were established in Holland and England.

The origin of the sugar industry is naturally shrouded in the darkness of a time very far past. We consider the word sugar to be derived from the Persian *shukkar* which, with the Arabic name of the same pronunciation, comes from the Sanskit *sarkara*. It is, however, impossible to tell from ancient writers whether the substance frequently

[1] Sommerville Lecture delivered April, 1889.

alluded to as resembling honey and used in medicine was sugar or not. Most probably it was, but in the form of syrup and not at first in crystals.

Galen and Pliny, in the beginning of our era, spoke of a substance called *saccharum* found in Arabia Felix, and only used in medicine, and in the Bible we all know of the mention of sweet calamus and cinnamon in Solomon's song, and of sweet cane in Isaiah and Jeremiah. Herodotus speaks of manufactured honey, and Nearchus, one of Alexander's admirals, tells of a reed which gave honey without bees.

Moses Chorenensis, however, is the first writer to mention the boiling of plants, in this case sugar-canes, for the extraction of sugar, and the first European home of the sugar industry was in Sicily where Frederick Barbarossa found many factories when he invaded Italy in 1121. From Sicily the culture of the cane gradually spread into Spain, and from thence was carried by the Spaniards into the West Indian Islands and Brazil. Here it found a congenial climate similar to the Indian one, from whence it came, and soon it became a source of great wealth, there being no less than twenty-eight sugar factories in San Domingo in 1518. It became apparent that the cane was meant to flourish in tropical countries and the cultivation in Europe died out, so that for over 300 years sugar came to Europe over the sea from equatorial countries and was produced almost entirely from the sugar-cane, which had come to be looked upon as the only practical source of sugar.

In the year 1747, however, a German chemist named Markgraf announced the discovery of 6 per cent. of sugar in certain sorts of roots which grew in northern Europe. This was looked upon as a botanical fact of small value to the world at large, until another German named Achard erected a little factory on his farm at Cunern near Breslau, and began actually to produce fine white sugar from Markgraf's roots. Furthermore, he made money at the same time, which was vastly more important, and drew the attention of all thinking men to the fact that a new source of wealth had arisen in Europe. From that moment, in fact, a mighty rival to the

veteran sugar cane appeared. It might have been long, however, before it could have coped successfully with foreign sugar, had not the first Napoleon, whose eye was as keen in peace as it was in war, lent his mighty help to the struggling industry in France, where Crespel Delisse and a few others, recognizing the value of Achard's results, were striving to establish the new industry on a firm footing. The result was in accordance with the Emperor's favorite maxim that God favours the heaviest battalions, other things being equal, and beet sugar rose steadily in France. Germany followed the good example, and then Holland, Belgium, Austria and Russia took it up. To-day out of five million tons of sugar consumed in the world per annum, more than half is made from the sugar beet. The rest is made from the sugar-cane principally, and some from the date-palm, the sugar-maple with which we are familiar, and the sorghum or bastard sugar-cane. The only plants which deserve any extended notice are the cane and the beet, for they alone are of commercial importance. The sorghum is capable doubtless of great things, although, up to now the costly and valuable experiments of the United States Government with it, have not resulted in much progress among the growers of the plant.

I will speak first of the sugar-beet, as it now occupies first place as a sugar-producing plant in the world, and bids fair to hold its own against all comers.

The sugar beet is a hardy biennial plant, indigenous to the south of Europe. We are all familiar with the shape of the ordinary mangel wurzel, and it resembles this more than any other, being white in the flesh and not *red* as many suppose. It is smaller than the mangel and much heavier in proportion. When from good seed and properly cultivated, it grows entirely beneath the ground, only the collar, from which the leaves spring, showing. Extensive experiments and cultivation have produced an immense number of varieties, but the origin of the rich sugar beet is the old root known to botanists as the *Beta alba*. Only the part which grows below the ground is valuable to the

sugar-maker, but the leaves and collars make first rate cattle food. Sugar beets are propagated from seed entirely, which is produced by the plant in the second year of its growth. The seed is sown early in the spring, in long drills, and now almost entirely by machinery. The drills are usually about eighteen inches apart and every year efforts are made to sow them closer, for the farmer as well as the manufacturer likes small and heavy beets rather than large and porous ones.

In about a week's time the small plants show themselves above the ground and all attention is paid to the thinning out. This is a delicate process which must be done by hand and on the proper performance of it everything depends. The plants are taken out so as to leave only one by itself, every eight or nine inches in the row, and children are found to be best adapted for the work. In the beet districts there is a continual struggle between the school authorities and the farmers as to who shall have the children in the spring time, and the school inspector usually has a hard time, for he has to contend with the parents and the children themselves, as well. I have seen as many as fifty boys and girls working slowly across the fields in a long row, and in Bohemia often three times as many, all of whom ought by law to have been in school. And often have I seen a sudden stampede from the fields, led by the overseer himself, at the sight of a gendarme in the distance. In fact in my apprenticeship days, I have several times found it very advisable to depart from the fields with more rapidity than dignity and to let the youngsters take care of themselves, which Bohemian children are well qualified to do. After the beets are thinned out the fields are left alone for a few days to allow the young plants to gather strength, and then the weeding and hoeing begin. This is done now almost entirely with machines drawn by horses, which keep turning up the ground and destroying the weeds between the rows, until the leaves of the beets get to be large and begin to cover the ground completely. Then they are left to themselves till the fall, when in the latter end of September they

are taken out. At this time the leaves are yellowish and the root firm and heavy, the growth being ended for the first year, while in the root is a store of sugar, which it has accumulated for further use, as bees do honey. But before it can get a chance to use the sugar in the second year's growth, the manufacturer takes it out of the ground and carries it off to the factory. The harvesting is done either by hand, loosening the roots with a narrow spade and then pulling them out, or by special plows for the purpose. The leaves and heads are cut off on the field and the roots transported to the factory for immediate use, or put into what are called *silos*. These are large piles of beets covered over with eight or ten inches of earth to keep out the frost. It is a simple and good way of keeping any roots, and now universally adopted instead of the costly buildings or cellars of former years. In these the beets may be kept safely until they begin to grow again, which time depends much on the weather and the country. In France it is difficult to keep them after New Year's day, while in Germany they may still be in good condition in February. In Russia and Canada they are perfectly inactive as late as the end of April, owing to the continuous cold. Once the sprouting begins, a series of chemical changes takes place in the root, the principal one being the transformation of the crystallizable sugar into another form which is useless to the manufacturer. On the other hand the beets may be frozen without damage, always supposing that they are worked up while still frozen, for, inasmuch as the freezing kills them, they rot as soon as they thaw, and the process of putrefaction partially destroys the sugar as well as makes the work in the factory well nigh impossible.

In the culture of the sugar beet, the two primary considerations are, first the seed and then the soil. On the kind of seed depends, entirely, the richness of the beet and, the soils being the same, the size of the beet. Small beets are usually rich, large ones poor in sugar, and the great object of the manufacturer is to get as much sugar as possible per acre. The different kinds of beets are crossed and re-crossed

until finally the proper beet for the particular country is got at. It is remarkable, indeed, to note how the roots have increased in richness in the past twenty years. Then six to eight per cent. was common in Germany, but now they will not have anything under 15 per cent. with an ordinary crop, and plant seed beets which contain over 20 per cent. The man to whom the honour of this improvement is due is Vilmorin, of Paris. He took the old Silesian beet and by long and careful cultivation produced a small beet containing a great deal of sugar, and also very pure. Every year the German, Austrian and Russian seed growers buy from him at whatever price he likes to ask, and keep improving their stock until now they export seed back to France, for all this time the Frenchman could not appreciate their countryman's efforts, and continued to grow the old cattle beet until the Germans got so far ahead that they exported sugar into France. In 1884 came a terrible crisis, and all turned their eyes to Germany to find that they were far behind, and all on account of bad seed.

The nature of the soil has a double effect on the beet. It affects the size of the crop and also its quality. Beets may be considered as consisting of five to six per cent. of what is called mark or insoluble fibrous matter, and 94 to 95 per cent. of juice. In this juice the sugar is dissolved and also, unfortunately, a number of other substances, which are salts of lime and potash joined to organic acids, and various complicated gummy matters. The presence of these is the cause of molasses. That is to say, the more of them, the more molasses, and the less pure sugar results from the process of manufacture. It is, therefore, of great importance that there be as little as possible of them, and their presence is determined greatly by the nature of the soil and the manure which is used. It is practically true that the only substances a plant derives from the soil, are phosphoric acid, nitrogen, and potash, and, therefore, manures are only of value inasmuch as they contain these substances. Of these, the one we wish most to avoid is potash, and it is a fact that this is a substance for which a beet has a most unrea-

sonable fondness. It will absorb potash just as a child will eat candy, and grow large and coarse, yielding an impure salty juice of small value. Wherefore potash is used very sparingly, only in fact, where the absence of it in the original soil is so marked as to render an addition absolutely necessary for the life of the plant. Again nitrogen is an element to be avoided in excess, for its use results in large spongy beets, which will not keep and yield impure juices which are very difficult to handle. The chemically inclined readers of this paper will be interested in hearing that a strong odour of nitrogen peroxide is frequently observed in the factory where the beets are obtained from dark rich soils, or those on which a Chili saltpetre is used in excess. And when such beets are decomposed by heating in the silos, they give out in the process of manufacture, inflammable gases which often cause violent explosions.

The remaining element of nutrition which the plant requires, phosphoric acid, is the greatest friend the sugar-maker has. It counteracts the alkalies in the juice, forming a harmless combination, and has also a ripening action which is most valuable in backward seasons. Therefore, when manuring, we add to the soil plenty of phosphoric acid and a little nitrogen, while potash is generally forbidden; and in selecting a soil we avoid very rich ones, or alkaline ones, and select a light, warm one if possible. But really, the only way to tell whether a certain soil is fitted for the culture of the beet as a general rule, is to sow some seed and see what will come of it. Chemical and physical considerations are wonderfully helpful in agriculture and have revolutionised that science, but up to now no chemist can tell what a given soil is best adapted for by analysing it, unless of course there be certain very marked characteristics. As a rule, however, beets will grow almost anywhere, and will stand more rough usage from the weather than any other crop. Their greatest enemy is water in the subsoil, which kills the young roots as soon as they reach it. Deep and thorough cultivation with plow and grubber is absolutely necessary, and this fact, and the

one that nothing repays care so well as a beet, have caused a revolution in the state of agriculture wherever beets are grown in any quantity. It is the only crop grown by man on whose quality everything depends, and the only one which is subject to severe scrutiny. It is true that barley is also carefully examined by the maltsters, but we do not hear of careful chemical analysis of barley, or hundreds of thousands of dollars spent in the mere propagation of the seed. When a farmer grows a crop of beets, and knows that the more sugar they contain the better for him, he takes care to find out the best way to manage his soil. And this care produces a great effect on all other crops. Instead of ploughing three or four inches deep, he goes down to fourteen inches, and he keeps his land clean. He also begins to understand about manures. In this country, for instance, the farmer will buy anything that looks black and smells bad, or will take any artificial manure you may offer him on trust. But the beet grower calmly offers so much per pound for potash or nitrogen or phosphoric acid, and cares not a bit whether these elements are in guano, or Chili saltpetre, or sulphate of ammonia, or anything else. Of course there are enlightened farmers in all countries, but in beet districts such accurate knowledge is universal.

Beets are most extensively cultivated now in the tract of land extending from Paris and Prague on the south, to the Baltic Sea on the north, and between the German Ocean on the west and the Russian boundary on the east. In Russia, the beet fields extend from Kiew to Moscow principally. Several attempts have been made in Italy without success, and in Spain as well; the ignorance and backwardness of the farmers in these countries was the greatest difficulty. In California, beets are now grown extensively, but experts seem agreed that, of all countries, Canada is the best adapted to this industry. Let us hope that this opinion will be justified in times to come.

So much for the beet. Now let us turn to the sugar-cane, the other great source of sugar to the world. It is still, I may say, looked upon by many as the only source, so

little do we often know about the commonest things in life. The cane has now been cultivated for nearly a thousand years, but almost entirely in tropical countries, and, therefore, under the management of tropical peoples. Genius, we are told, lights her lamps in northern latitudes, and the way in which northern nations have succeeded in competing in the sugar markets of the world, through the sugar-beet with the sugar-cane, is certainly a most pointed instance of the truth of the old proverb. For it is only in the last few years that intelligent work is being done in the cane sugar countries, and that under the stimulus of German and English engineers. But even yet, the waste on a cane sugar estate is appalling to the scientific sugarmaker of Europe, and things are altogether in a backward and inefficient state. In consequence, we have not the same accurate knowledge concerning the cane as a plant that we have about the beet.

The sugar-cane is a sort of enormous grass belonging to the genus *Saccharum*, and known as the *Saccharum officinarum*. There are an immense number of kinds, but probably all are from a single species of which they are varieties, the differences being induced by cultivation in different soils and countries, and, indeed, consisting often in only a different name. The vast area over which the cane is grown has resulted, indeed, in a greater number of names. We have, for instance, the Bourbon cane, the Otaheite cane, the Batavian cane, the large red cane of Assam, the black and yellow Nepaul cane, the Chinese cane, the Seelangore cane, the last named being, perhaps, the finest kind known. The South Pacific islands, probably the original home of the cane, produce many varieties with unpronounceable names.

The principal differences are in the colors of the leaves and stalks, which range from black or purple to green or red. The yield per acre and the percentage of sugar is also most variable, and has hitherto been a matter more of accident than anything else, owing to the backward state of the whole industry which I have mentioned above.

In appearance, the cane is a plant with a knotty stalk surmounted by a bunch of leaves, and from six to ten feet high. At each joint or knot, there is a leaf and an inner joint. The number of joints in the stalk varies from forty to eighty, and these joints are peculiar structures which it is difficult to describe clearly without proper diagrams. They are the parts in which the juice is perfected, and each encloses the germ of a new cane. The cane is propagated in the same way as potatoes, by means of these eyes or joints, as up to now no sugar cane has been known to perfect its own seed. The cuttings are taken from the most healthy canes and usually from near the top. They are planted very carefully in straight rows some two or three feet apart, and begin to sprout in about a fortnight. They are then carefully banked with earth from time to time as they grow, until there is a little hill all round the cane very much like the way our own Indian corn is treated. At the same time weeding and trashing is carried on, the latter operation being the removal of all dead leaves and suckers—a most important point.

There is another method of propagation which ought to be mentioned, namely *rattooning*. This is merely allowing the new cane to sprout up from the old root or stool as it is called. It is remarkable that in some countries as in Bengal, good rattoons are never seen, while in Jamaica all canes are re-produced in this way. It entails a smaller yield but a surer crop. In harvesting, the canes are cut as close to the stool as possible, the leaves and tops discarded, the rat-eaten canes put aside, and the sound ones transported to the mill. This is done, usually, by horses or mules but often wire tramways stretch across the plantations, or navigable trenches are laid out on which flat boats are propelled and the cane conveyed on them.

The yield per acre of cane, varies a good deal in different countries. About 25 tons in Louisiana is a good crop, while in Barbadoes 30 tons is common.

Canes contain all the way from six to twenty-four per cent. of sugar and may be said to be richer as a rule than sugar beets.

What has been said concerning the effect of soil and manure on the sugar beet applies, in a general way, to the cane. Plenty of phosphoric acid and as little nitrogen and potash as possible is the general law to be guided by, although the number of empirical rules about the best manures for canes, is large and confusing. The kind of climate is a more important consideration with the cane than the beet. It is not a hardy plant and needs great heat and considerable moisture. Thus it is that canes grow best on tropical islands or on the coast. Warm inland countries, even where irrigation can be practiced, are not nearly so well suited. As in the beet, the development of the sugar in the cane is greatly helped by warmth towards the end of its period of growth, and altogether it may be said that the cane wants just what the beet does, to manufacture its sugar, but wants the conditions intensified. The fight between the cane and the beet is now a bitter one. It will probably continue for all time, but the beet will get the upper hand gradually, inasmuch as it is of great benefit to the country at large, indirectly, that is to say, otherwise than as a sugar producing plant. The refuse of a beet factory ranks among the finest cattle foods in the world, while that from the cane is good only as fuel. The culture of the beet raises the general state of agriculture to the highest pitch of perfection, while that of the cane excludes other crops.

Let us now see what becomes of the ripe cane and beet after it arrives at the factory. These are very large buildings nowadays, filled with expensive machinery and not insignificant little places as many people suppose. To be sure there are still a few which are not extensive, and the most primitive and curious one is probably that now working on the banks of the Ganges. It consists of the stump of a tree with a hole in it, in which is a conical crusher driven by an ox at the end of a long beam. Two or three canes are squeezed in it at a time and the resulting liquor boiled in an iron pot alongside.

Then in China and Manilla the cane is grown in small patches and by poor people, and the canes crushed anyhow

and the liquor boiled down to a thick mass without any purification. Much of this sugar is refined in Montreal to-day, and it resembles earth in appearance. Sugar is also made, as we know, from the maple by simple concentration of the sap, which, however, is so pure that the product is very fine. That made from the date palm and called jaggery, is also merely juice boiled down in any kind of a pot, but n countries where a great deal of sugar is produced, as in Cuba or Java or Germany and France, things are carried on in a different way, factories work all the way from 200 to 2,000 tons of raw material in twenty-four hours, and are worth anywhere from $200,000 to $500,000 a piece.

I will give a general description of a beet sugar factory, inasmuch as it is much the more perfect and extensive and will include nearly all that may be said about a cane sugar one.

On approaching the factory, the beets are seen in great heaps outside in process of delivery by the growers. From these heaps they are carried by various appliances to the first step in the process of manufacture, that is the washing

The conveyance of these beets was long a puzzle to manufacturers until a German named Riedinger, a few years ago hit upon water sluices as the best means, and now they are everywhere adopted. The beets are tossed into the sluice which carries them along to an elevator. This lifts them up a certain distance and throws them into the first washer, which is a drum revolving in a tank of water. They are next thrown into a second washer which consists of a water tank in which great arms revolve and throw the roots about, carrying them forward at the same time and throwing them on to an elevator which lifts them up to the top of the building. If the washing has been properly done, the beets are now quite clean and ready to be cut up.

The form into which the roots are now reduced depends entirely on the method of extraction to be subsequently followed. In former times they were rasped up into an almost impalpable pulp and afterwards the liquor was pressed out by hydraulic presses of great power, or by roller presses of

various kinds and shapes. This was always a most unsatisfactory way, and has been entirely superseded by what is called diffusion. Wherefore, instead of being rasped, the roots are sliced up into long, narrow slices and run by suitable means into an apparatus called a diffusion battery. This consists of a number of cylindrical iron vessels, holding each about one ton of cut beets and communicating with each other by means of valves and piping. In it the slices are, so to speak, soaked out with hot water, passing from one to the other. It is not, however, a mere solution that takes place but a curious phenomenon known to chemists as osmosis.

This may be described as follows: If you have a vessel divided into two parts by a porous membrane such as parchment, and in one part water, while in the other there is a solution of crystallizable and uncrystallizable salts together, the crystallizable ones will pass through the membrane into the water on the other side, while the others, or colloid ones, as they are called, will not. This is what takes place in the battery. The long, thin slices of beet are placed in water of a particular temperature, and the cell walls of the root act as the membrane, allowing the sugar, which is crystallizable, to pass through into the water while other matters remain behind. Unfortunately there are other crystallizable matters besides sugar, and these go through also, and the broken cells of course give up all their contents to the water. So the resulting solution is still impure enough, but it is much purer than the liquor obtained in the old way, and the process is more rapid. The process is a continuous one, the liquor being passed from one cell to another until it has passed through ten or eleven, when it is drawn off. One end of the battery is continually discharging the liquor and the other the exhausted slices, which latter are pressed and sold for cattle food, while the liquor is further treated. It is very thin, black in color, and quite opaque. It would be quite possible to boil it down now to a thick syrup and let it crystallize out, but the result would be black sugar, and very little of it, so it must

be first clarified. This is done in what are called defecation tanks, and by means of a peculiar application of lime and carbonic acid. As both these substances are used in large quantities, there is a lime-kiln always attached to the factory, in which lime-stone or carbonate of lime is burnt and the resulting gas and quicklime collected.

The defecating pans are wrought-iron tanks holding about 700 gallons each, and provided with steam coils for heating, and perforated coils for the injection of the gas, which is sucked from the kiln by means of a large pump, and forced into them and up through the liquor.

The operation is as follows:—The tank is filled about three-quarters full of the black liquor from the battery, which has previously been heated to boiling point, and a certain quantity of lime is added (usually about 2 per cent. on the weight of the beets) in the form of lime milk. This causes an immediate partial clarification, and the whole is a gummy mixture, light in color. Then the gas is pumped through until, by a simple test, we know that it has precipitated very nearly all the lime that was put in. This precipitation completes the clarification begun by the lime, as it seems to drag down small suspended particles and coloring matters with it, to the bottom of the tank. The action is not very well understood, but the result is a very bright, clear liquor of increased purity.

We now have the defecator filled with a nearly boiling mixture of lime and sugar-liquor, and the question is to separate the one from the other. This is done in what are called filter-presses, which are machines so constructed that the mass is forced into spaces between coarse cloths held in iron frames, so that the liquor runs out clear through the cloths, and leaves a thick, nearly dry, cake behind. The cake is thrown outside, to be used as manure, and the liquor passes into the next stage, which is a simple repetition of the defecation, in which a little lime only is added and the gas passed through until there is but a trace of lime left. It is necessary to repeat the operation in this way to get a really good clarification. It is again filtered, and is

now very thin still, but perfectly bright and clear, and is ready for concentration. This is done in two stages: first, it is thickened to a syrup, containing 50 per cent. of sugar, in what is known as a double or triple effect. This is a peculiar and ingenious apparatus constructed first by a Frenchman named Rillieux, and consists of two or three cylinders about ten feet in height and six feet in diameter. They each contain a series of vertical or horizontal steam pipes for boiling the liquor, and communicate with each other, so that the vapor from the boiling liquor in the first boils the liquor in the second, and that from the second boils the liquor in the third. In this way we greatly economise the heat.

There is a further peculiarity about the machine, and that is, that to the third cylinder is attached an air pump, which sucks all the hot vapor from it as the sugar boils, and draws it through a stream of cold water, thus producing a vacuum. The object of this is to evaporate the water in the liquor at a low temperature, for, by the well-known law of physics, the less the pressure on the surface of a liquid the less heat it takes to cause it to boil—that is, to evaporate. We do not do this to save fuel, for we have to use more than we gain in driving the pump, but we do it to save the sugar, for if sugar-liquor is boiled at the pressure of the atmosphere, it becomes partially destroyed by the heat and gets quite dark in color. The boiling of liquor in a vacuum is the greatest advance made yet in sugar-making, and was known long before the principle of the multiple evaporator. In fact, the vacuum pan, which is the next piece of apparatus we have to consider, was long the great centre of the sugar factory, and the most difficult and important process was the boiling of sugar, We do not look on the matter now with the same awe that our progenitors did, but consider it still a most important station.

The syrup on leaving the evaporator is now quite thick and is dark brown in color. It is customary now, in the best factories, to boil it up at once in the vacuum pan, but many still adhere to an older process, that of bleaching by

animal charcoal or by sulphurous acid gas. This will produce brighter sugar, but we do not value this much, as the refiner, to whom the raw product is sold, buys it by its analysis and does not care much about a small difference in color.

The pan is an iron or copper cylinder, furnished with a great number of steam coils and an air pump and condenser. It may be any size almost, but usually is about nine feet in diameter and ten feet high.

It is not an easy matter to boil sugar well if it be of a low grade, and long experience is valuable. In refineries, good boilers get high wages, for the yield depends much on them; but they are commoner now than they used to be. The general operation is this. The pan is partially filled with liquor, and the steam turned on the lower coils so that the liquor is gradually boiled down till quite thick. Then the boiler opens the valve suddenly and takes in a small charge, shutting again quickly. The result is usually that crystals began to form in the pan, and after a little he takes in another charge. Sometimes, however, there is great trouble in forming the grain as we say, and charge after charge is taken in, and the amount carefully varied until at last we do get some grain. Then the panman proceeds cautiously to nourish the grain which is at first very small, by carefully regulated charges. This done, the operation proceeds more rapidly and all the panman has to do, usually, is to watch his vacuum guage and thermometer, and keep taking regular charges till the pan is sufficiently full. Then it is concentrated a little more and the work is done. The liquor has now become a thick sticky mass of syrup and sugar crystals of the consistency of putty, and brown in color. Had the syrup been boiled in the open air, it would have been nearly black, but by reason of the vacuum, the temperature has been kept down to 150°, and may be kept as low as 110°, and it has merely got browned a little. The panman tests his pan by taking out little samples, and examining them on a piece of glass, or by feeling them and as soon as he is satisfied, he shuts off the steam, lets in the

air to destroy the vacuum and opens the pan below, dropping the contents into a long receiver, which is placed over the centrifugal machines.

Centrifugals are vertical drums whose periphery is made of perforated brass plate or brass wire gauze. A portion of the masse cuite, as it is termed, is let into them from the receiver, and they are then set in rapid motion, making 1,500 turns per minute. The masse cuite is thrown violently against the perforated plate, and the syrup finds its way through the holes and into the outer casing from which it runs to tanks below. In the centrifugal, the sugar is left in a nearly dry state. It is light yellow in color, of a well-defined grain and has a salty taste. It is quite easy now to make it white by throwing a little water on it, while the centrifugal is in motion, or sending a jet of steam through it, but as this melts so much of it, and besides has only a partial whitening effect, it is now abandoned in most places, and yellow aw sugar is produced.

This is called the first product and amounts to from six to thirteen or more per cent. on the weight of the beets according to their quality.

The syrup which runs off, is still of considerable value, as it contains fully two per cent. of sugar on the weight of the beets. It is utilised by boiling it up again and then letting it stand in a hot room until the sugar gradually settles out of itself. Then it is again put into the centrifugals and a second product is the result, which is darker and less pure than the first product.

The resulting syrup now will hardly crystallise any more, by reason of its impurity, and so special means are taken to get rid of the impurities, which have gradually increased in proportion as the sugar has been extracted, until they now form a great percentage. It is found by practical experiment that if the sugar in a liquor does not represent more that 60 per cent. of the total solids dissolved in that liquor, some special purification is needed. When the liquor left the clarifiers it had 85 per cent. of the total solids, as sugar now there is only 60 per cent. This has

2

been a fruitful field of investigation for chemists for many years, and all efforts have been made to combine the sugar with some substance and so separate from its impurities.

This can be done by forming what are called saccharates of lime, or barium, or strontium, which are decomposed afterwards by means of carbonic acid or of heat.

The factories erected for the strontium process are much larger and more complicated than the original sugar factories and would entail too long a description. The lime processes are simple ones, but scarcely of general interest, so I will dismiss them at once.

There is another and peculiar process which is older than the others, and still a good deal used, depending on the principle of osmosis which I mentioned before in connection with the diffusion. It is cheap but slow. Any one of these processes may be used to get at the last of the sugar in the molasses, but also the molasses may be distilled and the sugar turned into alcohol. This used to be the universal custom, but now it is found to pay better to extract the sugar.

This ends the manufacture of the raw beet sugar. It is put into bags and sold to refiners. Very few factories turn out refined sugar, that is, combine the two processes, for, as a rule, it does not pay.

I will now briefly point out the differences between a cane and a beet sugar factory. The processes are either very similar or identical. The liquor is, however, extracted almost universally by crushing under immense rollers instead of diffusing, which latter process is but of doubtful value where cane is concerned. The clarification is made by means of lime alone without carbonic acid, and in a crude way enough as a rule. The evaporation and concentration in the multiple effect and vacuum pan are the same, but these are only to be seen in the more advanced districts.

Centrifugals are also used now in many places and, in fact, the cane sugar men are copying closely beet sugar methods. The products of a cane sugar factory are divided into several classes like that from a beet sugar one, the chief difference

being that the molasses is either sold for direct consumption or distilled, the saccharate processes not being applicable for the extraction of sugar.

Crude or raw sugar from a factory is now almost always sold to a refiner to be turned into white or yellow sugar. Refineries resemble raw sugar factories in a few points only. They are very large places containing storehouses and cooperages as well as the machinery. A fair sized refinery will work 200 tons of raw sugar in twenty-four hours and the general process, I will briefly describe. On arriving, the raw sugar is melted in a large cistern of hot water in which arms revolve. Sugar is put into the water until the contents of the cistern are half water and half sugar. This liquor is then pumped up to the top of the building and heated boiling hot. Next it is filtered through cloth bags, from which it runs very clear and limpid. After this it goes to the char tanks. These are immense cylindrical iron vessels containing about 25 tons of charred bones or animal charcoal as it is called.

This substance has the peculiar property of decolorising liquor. A dark brown syrup often being in contact with it for a short time will become as clear as water. After passing through these it is collected in cisterns, concentrated in vacuum pans and the masse cuite worked off in centrifugals. Owing to the action of the char, the sugar is white or light yellow according to how much charcoal has been used in proportion to sugar melted. The syrups that run from the centrifugals are boiled up again and allowed to crystallise out, or are sold for consumption according to their strength. On the whole, the process is much simpler than that used in a raw sugar factory, but everything is on a much greater scale. A very important part of a refinery is the char house, this is a place where the char is reburnt after having been used in order to serve again, which it is made to do many times, until finally being exhausted it is sold for artificial manure.

Concerning the chemistry of sugar, I can say but little, as it is too extensive and complicated a subject to be dealt

with in a paper of this sort, however, I may say that the sugars belong to the great chemical division called the hydrocarbons and are divided into two great groups, called the glucose group whose formula is $C_6 H_{12} O_6$, and the cane sugar group whose formula is $C_{12} H_{22} O_{11}$. Of the first named group, the principal member is common glucose, a widely distributed substance in nature, which is usually artificially prepared by treating starch with sulphuric acid. It is often considered as a deleterious substance and used to adulterate sugar, but, although it is my natural enemy, as a sugar maker, I must admit that it is just as harmless and wholesome as the best of sugar, and its only fault is that it is not over one-third as sweet. It may be produced in many curious ways, for instance in the human body by the irritation of the medulla oblongata, or from this very desk by means of sulphuric acid. To this group belong also levulose, inverted sugar, sorbin, inosit, and many rarer kinds.

The chief member of the second group is cane sugar or saccharose, which we have been discussing. It is called cane sugar, but occurs in many plants as the sugar beet, the maple, etc., as we have seen. To this group belong milk-sugar, maltose, and many others.

Strange as it may seem, no chemist has ever been able to make sugar from a foreign substance. The plants know how to do it, but we cannot. Nor has anybody ever been able to turn glucose into cane sugar, although the difference in their formulæ is but a molecule of water. Could this be done easily, no more sugar-canes nor beets would be grown, but we would use up old rags, sawdust, and all sorts of detritus. Every year somebody reports success in this quarter, but no results are forthcoming. The sugar world is used to such scares, but it got a bad one a little while ago when Prof. Remsen, of Johns Hopkins' University, made from one of the derivatives of coal-tar, toluene, a substance called benzoyl sulphonic amide, or as it is now termed, saccharine. This is one of the chemical curiosities of the present day. It is a white powder, slightly soluble in water, and 280 times as sweet as sugar, that is, one pound

of saccharine will sweeten as much water as a barrel of sugar.

All sugar makers felt very uneasy when this came to light, but now it is known that it is harmful in its properties and valuable only as a medicine, those who own the five hundred million dollars invested in sugar in this world breathe again.

HOW IS THE CAMBRIAN DIVIDED?—A PLEA FOR THE CLASSIFICATION OF SALTER AND HICKS.[1]

BY G. F. MATTHEW, M.A.; F.R.S.C.

A new classification of the Cambrian system has lately been proposed by Mr. C. D. Walcott, the well-known palæontologist of the United States Geological Survey and has received the assent of Prof. Chas. Lapworth. The most prominent feature of this classification is the basal position given to the Olenellus fauna which no doubt is in accordance with facts. Another point in this classification is the placing of the rocks containing the Paradoxides fauna as Middle Cambrian; with this the knowledge at present before the writer does not seem to agree. A while ago it seemed as though the Cambrian system was divided palæontologically into three sections, the Paradoxides beds, the Lingula flags and the Tremadoc or Ceratopyge beds, which would thus be the Lower, Middle and Upper Cambrian. But this "Upper" Cambrian was not only weak in bulk of measures, but in the genera it contained it exhibited a strong palæontological affinity to the Ordovician forms, so strong, indeed, that by many European geologists it was classed as a part of the "Lower Silurian" system.

The discovery by Mr. Walcott of many of these so-called Ordovician forms, low down in the Cambrian strata of the Rocky mountain region, shows that a different interpreta-

[1] From the American Geologist, September, 1889.

tion may now be given to these forms, for they do not by their presence exclude the Ceratopyge or Tremadoc beds from the Cambrian. Nevertheless, under the classification proposed by Messrs. Salter and Hicks some twenty years ago, the Cambrian is divided into two great divisions only. The purpose of the present article is to review some of the evidence touching the faunas and the sedimentation of this system, and to compare the proposed division with that presented by Dr. Hicks.[1]

Late discoveries in America and Europe, and especially the enlargement of the fauna with Olenellus and the discovery, or rather the determination of its proper place in the Cambrian succession, has led to this proposal for a new allotment of the parts of the Cambrian system.

If the object in view were merely the arrangement of the members of this system which may occur in any particular country, the sedimentation, or division into series, in that country could be utilized for the purpose, but as the object is a classification that will apply generally, other criteria must be sought. Among those which have been used are the succession of the several faunas and the relationship of the genera in each; and the comparative bulk of measures n the several parts of the system. These form the basis of the following remarks.

The Cambrian rocks as originally described by Prof Sedgwick no doubt contained the Ordovician or Lower Silurian as well as the strata to which the name has since been restricted. These (the Lingula flags, etc.) were also claimed by Sir R. Murchison as a part of his Silurian system. In later times the conflicting claims of these discoverers have been compromised by assigning to each his own special domain, and erecting the disputed territory into a separate system, the Ordovician.

The development of the Cambrian system from its original basis in the Lingula flags, etc., received a great impulse from the discoveries of Dr. Henry Hicks and the late Mr. J. W. Salter, in Wales; and especially in the find-

[1] Pop. Sci. Review, N.S. Vol. 5.

ing of the Menevian fauna in South Wales by Dr. Hicks.

In the process of elaborating the Cambrian faunas, the first step was the discrimination of the two faunas in the Lingula flags in 1853.

1865. In this year Messrs. Salter and Hicks made known the Menevian fauna, and showed the position of the Paradoxides beds in Britain.

1866. In this year the Tremadoc fauna was distinguished in South Wales, and fully confirmed in 1872.

1869. In 1869 Messrs. Hicks and Harkness described the great series of red, green and grey slates below the Menevian in South Wales, and showed the existence of a fauna older than that of the Paradoxides beds but with no trilobites.

Subsequently Dr. Hicks elaborated the Cambrian system into seven groups, but showing only four trilobite faunas, the first or oldest not having been found by him in Britain. The groups of sediments containing these faunas he classified as follows:

Lower Cambrian. Three groups.—Caerfai, Solva and Menevian.

Upper Cambrian. Four groups.—Maentwrog, Ffestiniog, Dolgelly and Tremadoc.

It may be well to inquire what there is to support this classification of the Cambrian system, before adopting a new one.

Two principal criteria for determining a question of this kind would be the facies and succession of the faunas and the bulk of the measures. In applying these tests, we turn our attention first to Scandinavia, for in no part of the world is there known such a clear, continuous and complete succession of Cambrian faunas as in that country.

Connection, etc., of the Cambrian faunas.

Of the several classes of organisms of these faunas, the trilobites may be taken as the group which will best show the relationship subsisting between the several faunas, for

they are the most varied, and were more sensitive to the changing conditions of environment than the others.

In Brögger's admirable work on the Stages 2 and 3 of the Palæozoic rocks of Norway, a table is given which shows the succession and range of the species in the Cambrian faunas of that country. Then as regards the neighboring kingdom of Sweden, Dr. G. Lindström's list (1888) of the fossil faunas of the Cambrian and Lower Silurian rocks is complete for the several zones of the Cambrian in that country. Combining the genera from these sources a full representation of Cambrian life in Scandinavia is obtained, so far as relates to the genera of the trilobites.

The first or oldest fauna presents the following genera:

OLENELLUS (by its sub-genus MESONACIS†)	* *Arionellus* (=*Agraulos.*)
* *Ellipsocephalus.*	* *Agnostus.*

Of these genera one is peculiar and three (marked by an asterisk) pass to the next fauna.

In the second fauna are the genera.

* *Harpides.*	*Solenopleura.*
PARADOXIDES (including *Centropleura.*)	*Arionellus.*
	Anomocare.
Ellipsocephalus.	*Dolichometopus.*
* *Liostracus* (includes *Ptychcoparia.*)	*Aneucanthus* (c. f. *Centropleura ?*)
	Corynexochus.
Conocoryphe.	*Microdiscus.*
Elyx (=*Ctenocephalus.*)	* *Agnostus.*

Here are fourteen genera of which three are found at higher horizons in the Cambrian system. Under *Liostracus* the Swedish palæontologists include *Ptychoparia* which with *Agnostus* has a wide range in the Cambrian system, so that with the exception of these genera the break is almost complete, between this fauna and that which follows. *Conocoryphe* as understood in Sweden does not extend beyond this fauna.

† The name of the leading genus (or genera) of each fauna is given in Roman capitals.

The third fauna contains the following genera:

Liostracus ?	*Leptoplastus.*
OLENUS †	*Eurycare* (s. gen. of Leptoplastus†
Parabolina (s. gen. of Olenus†).	**Agnostus.*

Here all the genera and subgenera are peculiar to this fauna except the ubiquitous *Agnostus* and Liostracus?

But the connection with the next fauna is closer than appears from the names, as some of the genera are closely related to those of the succeeding fauna. *Eurycare* especially is intermediate between *Leptoplastus* and *Ctenopyge.*

The fourth fauna has the following genera:

**Cyclognathus* (sub-gen. of Peltura †)	*Ctenopyge* (s. gen. of Leptoplastus †)
PELTURA.	*Sphærophthalmus* (s. gen. of Leptoplastus †)
Protopeltura (sub-gen. of Peltura †)	*Boeckia* (sub. gen. of Leptoplastus.)
Acerocare (sub-gen. of Peltura †)	
**Agnostus.*	

Cyclognathus is found also in a fauna above, but *Peltura* and *Ctenopyge,* with their related forms, especially mark this horizon.

The fifth fauna, which has a strong Ordovician facies, exhibits the following genera:

Cheirurus.	*Nileus.*
Pliomera.	*Symphysurus* (s. gen. of Nileus †)
° *Harpides.*	*Niobe.*
Remopleurides.	°*Holometopus.*
° *Triarthrus.*	*Conophrys.*
° DICELLOCEPHALUS	° *Parabolinella* (s. gen. of Olenus.†)
° CERATOPYGE.	*Amphion.*
° *Euloma*	*Ampyx.*
Megalaspis	°*Agnostus.*

Among these eighteen genera there are only about eight (marked by "°") which by their aspect recall the European types of the Cambrian trilobites, and probably for this

† See Brögger's Etagen 2 und 3.

reason the Swedish palæontologists regard this fauna as belonging to the Lower Silurian. But it evidently corresponds to the Tremadoc fauna, which by English palæontologists is reckoned to the Cambrian; and late discoveries in America show that *Nileus, Niobe,* &c., also are truly Cambrian.

In Wales, which has given its name to the Cambrian system, the succession of the faunas, their unity and their relative importance are much the same as in Sweden and Norway, but these features are obscured by the use of different names for some of the genera.

Mr. Robert Etheridge's catalogues in the Geology of North Wales are the basis for the comparisons made here. In them the genus *Conocoryphe* (as used by Mr. Salter) is made to serve for a number of Scandinavian and other genera. The figures of many of the species in this work are very imperfect, but for the purposes of this comparison the species in *Conocoryphe* may be distributed to *Conocoryphe, Ctenocephalus, Liostracus, Ptychoparia, Solenopleura, Euloma, Parabolina, Parabolinella* (?) *Conocephalites* and *Dicellocephalus.*

In Wales the first fauna has produced no trilobites unless *Conocoryphe viola* belongs here. The second Cambrian fauna has a full representation as follows:—

PARADOXIDES.	*Ctenocephalus.*
Plutonia (sub gen. of *Paradoxides.*)	
Anopolinus (c.f. *Centropleura.*)	*Carausia.*
Solenopleura.	*Conocoryphe.*
**Liostracus* (or *Ptychoparia.*)	*Erinnys* (c.f. *Harpides.*)
Holocephalina.	*Microdiscus.*
Arionellus.	**Agnostus.*

Here there are twelve genera of which two only extend upward to higher horizons.

The third fauna (Lower Lingula flags) has the following genera:

OLENUS.	**Euloma.*
**Parabolina.*	**Agnostus.*

Of these three extend upward to the higher zone, leaving only Olenus as peculiar to this fauna.

In the fourth fauna (Dolgelly group) are the following genera:

**Euloma.*	PELTURA.
**Parabolina*	*Sphærophthalmus.*
**Parabolinella* (?)	*Ctenopyge.*
**Conocephalites*	**Agnostus.*

Five of these genera extend upward into the next zone. The *Conocephalites* have been called *Dicellocephali*, but they are not the typical forms of *Dicellocephalus* with spined pygidium, which occur higher; they are related to *Conocephalites* (sens. strict) and *Conocephalina*,† which has short spines found by Brögger in the Paradoxides zone. The genus is not reported from the equivalent beds in Sweden, where the genera of the second column held possession, but it is found in the fauna of Hof in Bavaria.

The fifth Cambrian fauna (Tremadoc group) exhibits the following genera:

Psilocephalus	°*Euloma.*
Asaphus	°*Parabolina.* (?)
Cheirurus.	°*Parabolinella.* (?)
°*Angelina.*	°*Dicellocephalus.*
Nesuretus.	*Conophrys.*
Niobe.	*Ampyx.*
Ogygia.	°*Agnostus.*
Dionide.	

In this assemblage of fourteen genera only six represent "Cambrian forms" of trilobites, but in the lower half of the first column are a number of genera which, once thought to have appeared first at this period, are now found to be present in the West of America by representative forms at a lower horizon. Hence these, although hitherto regarded as Ordovician, as already remarked, are essentially Cambrian types.

It will be observed that in the Welsh area the four Cambrian faunas, which have trilobites, show a correspondence

† Om paradoxidesskifrene ved Krekling.

of genera with those of Scandinavia, and here as there, exhibit a very decided palæontological break at the summit of the Paradoxides beds. Hence Dr. Hicks was justified in dividing the Cambrian groups of strata into Upper and Lower, accordingly as they were above or below this horizon.

Having seen how the Cambrian faunas are related to each other in Europe, we may now examine their succession in the eastern half of North America.

To Mr. C. D. Walcott is due the credit of having determined the relation of the Olenellus fauna in this region to the rest of the Cambrian system.

The clearest succession of the lower members carrying unmistakable forms of this fauna is that which he has lately examined in Newfoundland. Combining the genera found there with those of the Champlain and Hudson valleys we find tbe following:—

OLENELLUS.	* *Zacanthoides.*
MESONACIS.	* *Olenoides.*
* *Paradoxides* (Shaler)	*Bathynotus.*
Avalonia (n. gen. not yet described.)	
* *Ptychoparia.*	* *Protypus.*
* *Agraulos.*	* *Microdiscus.*
* *Solenopleura.*	* *Agnostus.*

Of these thirteen genera it will be observed that two-thirds pass to the Paradoxides beds, and of the remainder, *Avalonia* is not described, and *Mesonacis* is by Scandinavian palæontologists regarded as congeneric with *Olenellus.* There is thus a much closer connection between this fauna and that which follows it, than there is between the latter and the faunas of the Upper Cambrian. Moreover, the embryonic and larval stages of Paradoxides and Olenellus show that these genera are closely related.

We have very little knowledge as yet of the way in which the Paradoxides fauna was related to that which follows it, since both in Newfoundland and Acadia the next zone has yielded very scanty remains of trilobites. Perhaps the Mt. Stevens section where the genus Paradoxides has been found [1] will yield the required information. In New-

[1] See this journal, vol. III, No. 1. (Jan. '89.)

foundland Mr. Walcott has found *Olenus*, and in the St. John area (Acadia) *Leptoplastus* occurs. In the latter area also the fourth Cambrian fauna has been found, being indicated by the presence of *Ctenopyge flagillifer*, *C. spectabilis* and *Orthis lenticularis*.

A fuller presentation of Upper Cambrian forms is that which is found in the Mississippi valley in the states of Wisconsin and Iowa, where there is a succession of 600 feet of sandstones whose fauna has been described and figured by Dr. D. D. Owen and Prof. Jas. Hall. The latter divides this series into three parts, the lowest of which contains forms similar to those at the base of the Olenus zone in Europe.

In the middle division, which is most prolific of the remains of trilobites, are species which may be compared to those of the genera *Olenus*, *Parabolina*, *Leptoplastus ? Euloma* and *Conocephalites*. Dr. Dames compares others to *Anomocare*. It is only in the highest Potsdam division and in the beds above it, according to Prof. Hall, that the typical Dicellocephali appear, and these in Europe are found in the Tremadoc or fifth Cambrian fauna. *Triarthrella* occurring in Wisconsin with these Dicellocephali is compared by Brögger to *Cyclognathus*, a genus of the fourth fauna and of the base of the Ordovician. The whole series of 600 feet in Wisconsin seems to belong to the Upper Cambrian. But the phase of the fourth Cambrian fauna represented in Europe and Acadia by *Ctenopyge* and its allies is absent, probably from the want of favorable habitat.

Comparative bulk of measures holding the faunas.

The relative age and position of the Paradoxides beds in the Cambrian system may be shown by the bulk of the measures in the different parts of the system. With our present knowledge, this can be only imperfectly done, but the following is a comparison of the mass of deposits in three different countries. When the system has been more carefully studied in different parts of the world a more exact proportion in the sedimentation will be had.

In Norway the Cambrian system has the following thickness[1] :—

			Ratio.
Stage 3*a*=Tremadoc or Ceratopyge fauna	45	feet	1.2
" 2*d-e*=Dolgelly or Peltura fauna	40	"	1.0
" 2*a-c*=Lower Lingula flags, Olenus fauna	110	"	3.2
" 1*c-d*=Menevian and Solva, Paradoxides fauna	80	"	2.3
" 1*a-b*=Harlech (?) or Olenellus fauna	80	"	2.3
	355	feet.	10.0

In Wales there are the following groups of Cambrian strata :—

				Ratio.
Upper Cambrian.	Tremadoc	1000	feet,	1.
	Dolgelly	600	"	.5
	Ffestiniog	2000	"	4.5 (Ffestiniog and Maentwrog)
	Maentwrog	2500	"	
Lower Cambrian.	Menevian	700	"	2.5 (Menevian and Solva)
	Solva	1800	"	
	Caerfai	1500	"	1.5
		10,100	"	10.0

In Acadia the Cambrian sediments are intermediate in thickness between those of Wales and Norway. The average of two sections in the city of St. John gives the following proportions :—

			Ratio.
Division 3=Dolgelly (and Tremadoc)	600	feet[2]	2.5
" 2=Ffestiniog and Maentwrog	1050	"	4.0
" 1=Menevian and Solva	350	"	1.5
Series A =Caerfai (?)	500	"	2.0
	2500		10.0

In Newfoundland Mr. Walcott has found the Olenellus beds to be about 600 feet thick and the Paradoxides beds 370 feet, which agrees nearly with the thickness of these portions of the Cambrian system at St. John (New Brunswick).

The Olenus fauna is found in Newfoundland, but apparently Mr. Walcott has not discovered there the fourth

[1] Die Silurischen Etagen 2 und 3.

[2] Above this is a thin body of slates with Arenig graptolites.

fauna (Peltura) or the fifth fauna. We, therefore, are still confined to the three countries of Scandinavia, Wales and Acadia as giving the most complete presentation of the sedimentation and life of the Cambrian period. Combining the ratios for these three countries we get the following result:—

		Norway.	*Wales.*	*Acadia.*	*General Ratio.*		
Fifth fauna....	Stage 3*a*	1.2	1.	1.[1]	1.1	6.	Upper Cambrian.
Fourth "	" 2*d*-*e*	1.0	.5	1.5	1.0		
Third "	" 2*a*-*c*	3.2	4.5	4.	3.9		
Second "	" 1*c*-*d*	2.3	2.5	1.5	2.1	4.	Lower Cambrian.
First "	" 1*a*-*b*	2.3	1.5	2.	1.9		
		10.0	10.0	10.0	10.0		

These facts do not favor the separation of the Paradoxides beds from the Lower Cambrian, or their erection into a separate division as Middle Cambrian. If there is to be a Middle Cambrian it would rather seem that the Olenus fauna holds this position. But as has been shown the faunal relationship of the Olenus beds to those which follow them forbids their separation, just as in the Lower Cambrian a similarity in the forms correspondingly connects the Olenellus with the Paradoxides fauna.

On the Occurrence of Leptoplastus in the Acadian Cambrian Rocks.

By G. F. Matthew, M.A., F.R.S.C.

It is somewhat singular that while species of Olenus have been found in Britain and elsewhere, the genus Leptoplastus, of which Angelin describes several species, appears to have been observed thus far only in Scandinavia.[2] Angelin seems to have thought this genus so important that he made it the type of a family, Leptoplastidæ, in which he included Olenus, Parabolina, Peltura, Acerocare, Eurycare and Sphærophthalmus. Leptoplastus may, perhaps, have been

[1] The general average is taken for this portion.

[2] I observe that Zittel (Traité de Palæontologie 1887, page 593,) mentions the occurrence of this genus in Great Britain, but does not give the source of his information.

regarded by him as a link between the first four of these genera and the two last, and thus most suitable for the family type. Within the genus there are species which ally it to Olenus and Peltura (*L. stenotus*, *&c.*), and also one (*L. raphidophorus*) which by its peculiar cheek-spines shows a relationship to Sphærophthalmus and Ctenopyge.

The most obvious distinction between Leptoplastus and Olenus is the position of the eyes, which in the latter genus are in advance of their normal position in trilobites; this difference is expressed by Angelin as "oculi subapicales" in Olenus, "oculi centrales" in Leptoplastus. In the latter genus the head is more strongly vaulted transversely, and the genal spines spread outward in a more decided manner than in Olenus. There are other differences, as the number of segments in the thorax, form of the pygidium, &c., which are not so easy to determine.

By the form of the head, &c., the Acadian species belong to Leptoplastus, and though we have not sufficiently perfect specimens to reproduce all the characters as given by Angelin, those known are sufficient for a description of the species.

LEPTOPLASTUS STENOTOIDES. N. Sp.

Head. Broadly semi-circular; crust, smooth. *Centre piece* of the head-shield sub-trapezoidal; strongly arched transversely, depressed in front of the glabella; marginal fold distinct, elevated. Glabella ovate-cylindrical, indented on each side by a pair of furrows which are moderately inclined backward. Occipital furrow distinct, impressed all across. Eyelobes prominent, ocular fillet faint. Occipital ring rounded backward.

Cheeks arched upward in the middle, depressed at the posterior furrow. Movable cheek broad, with a rather wide marginal furrow and sharp flaring genal spine about as long as the inner area of the cheek. Posterior furrow distinct.

Pygidium nearly semi-circular (longer than half the width), with a broad, flat margin. Rachis distinct, extending to the marginal furrow, divided into three distinct and two or more faint rings; lateral lobes with three furrows.

Hypostome (found loose with this species), sub-rectangular, rounded in front, truncated at the posterior corners; arched upward across the middle, depressed at the end and having there a narrow upturned fold.

Sculpture. Crust smooth.

Size. Length of middle piece of head 6 mm., width 10 mm. Length of movable cheek 11 mm., width 4 mm. Lengthof pygid. 4 mm., width 7 mm. Length of hypostome (?) 3 mm., width 2 mm.

Horizon and Locality. Calcareous layers in fine dark olive grey shales. Div. 3, Band *a*. St. John Group on Long Island, Kennebecasis River, N.B., in company with *Agnostus pisiformis, &c.*

This species is very near to *L. stenotus*, but differs from it (as figured by Angelin) in its conical glabella, more flaring cheek and spine and wider border to the pygidium.

LEPTOPLASTUS SPINIGER. N. Sp.

Head. Only the centre piece known. This is trapezoidal in outline, with a spinous projection in front and another behind. It is strongly vaulted transversely and has a distinct anterior marginal fold produced at the axial line into a sharp spine. The spine projects forward, and is about three-quarters of the length of the glabella. Glabella ovate-conical, with two pairs of short, slightly oblique furrows. Occipital furrow distinct, crossing the axis; occipital ring, broad in the middle, bearing a spine directed backward. Fixed cheeks strongly arched. Eyelobes prominent. Posterior furrow and fold distinct.

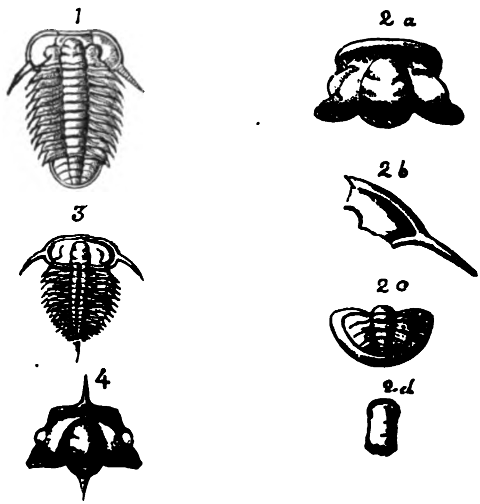
Sculpture. Crust smooth.

Size. Length, excluding spines, 2½ mm., with spines, 4 mm.: width, 4 mm.

Horizon and Locality. Occurring with the last species.

Among the Swedish Leptoplasti, *L. raphidophorus* is the one which in size compares to this, but it differs in many details. It also is a spinous species, but is not shown to possess the peculiar spine at the apex of the shield, which

gives to our species somewhat the appearance of an Ampyx. In Ampyx, however, the spine springs from the front of the glabella, and in some species is much longer than that of *L. spiniger*.



REFERENCE TO FIGURES.

Fig. 1. *Leptoplastus stenotus.* Ang. After Angelin.
" 2. *Leptoplastus stenotoides.* N. sp. Mag. $\frac{3}{1}$. 2*a* Middle piece of head shield. 2*b* Movable cheek. 2*c* Pygidium. 2*d* Hypostome found with this species. From Div. 3*a*, Long Island, Kennebecasis River.
" 3. *Leptoplastus raphidophorus.* Ang. After Angelin.
" 4. *Leptoplastus spiniger.* N. sp. Mag. $\frac{4}{1}$. Middle piece of the head shield. From Div. 3*a*, Long Island, Kennebecasis River.

In Sweden the beds with Leptoplastus are regarded as the upper number of the Olenus beds, as distinguished from those which carry Peltura and Sphærophthalmus. In New Brunswick, however, the physical conditions during the time when this genus lived were such as to associate it more closely with the later fauna. The two species of

Leptoplastus occur in the lowest of the fine slates which succeeded to the flags and slate of Div. 2, and lithologically the beds fall into Division 3.[1]

In the Acadian area no trilobites are yet known in the great mass of sediments intermediate between the shales carrying Leptoplastus and those which hold Paradoxides.

DERIVATIVES OF TOLIDIN.

R. F. RUTTAN, B.A., M.D.

In 1845 a Russian chemist named Zinin,[2] by reducing Azobenzol with hydrogen sulphide obtained a substance which, when further treated with sulphuric aicd, gave rise to a base called Benzidin. The intermediate product of the reduction of azobenzol was subsequently examined by Hofmann[3] and found to be Hydrazobenzol, and the nature of the reaction giving rise to Benzidin was made clear.

From a homologue of hydrazobenzol, viz.: hydrazotoluol by Hofmann's method, Petriew[4] prepared the homologue of Benzidin, viz., Tolidin, and studied some of its characteristics. The constitution of both Benzidin and Tolidin was afterwards established by Gustav Schultz.[5] These two bases were shown by him to be double molecules of anilin and toluidin, respectively, connected by their benzol neuclei, and having their amidogen groups in the para position. Their formulae being:—

$$\text{Benzidin}\left\{\begin{array}{l} C_6\ H_4\ NH_2 \\ | \\ C_6\ H_3\ NH_2 \end{array}\right. \qquad \text{Tolidin}\left\{\begin{array}{l} C_6\ H_3\ (CH_3)\ NH_2 \\ | \\ C_6\ H_3\ (CH_3)\ NH_2 \end{array}\right.$$

Benzidin has received some attention from chemists and many of its reactions have been investigated. Tolidin, on the other hand, owing to the difficulty with which it was

[1] In a former communication to this journal, they were referred to as probably at the top of Div. 2. (See July, 1889.)

[2] Journal für practische Chemie, xxxvi., 93.

[3] Jahrsbuicht der Chemie, 1863, 424.

[4] Berichte, vi., 557.

[5] Liebig's Annalen, 174, 227. Berichte, xvii., 467.

obtained, and its apparent unimportance, has received until lately no attention whatever. These two bases were long regarded merely as chemical curiosities whose chemical relations were of importance only so far as their existence threw light on other reactions, and thus aided generalization. A few years ago, however, Greiss[1] announced that benzidin, like anilin, formed a diazo compound on treatment with nitrous acid. From this Gustav Schultz, of Berlin, in 1879, prepared the first of the now important class of dyes called Azo-dyes from Benzidin, but the first economic dye of this class was patented in 1884 and named Congo red. These dyes, now very numerous, owe their importance in the arts to the fact that they dye wood and cotton fibre directly, *i.e.*, without the use of a mordant.

The success of the Congo red and other dyes of this class lead to the preparation of these rare bases, Benzidin and Tolidin, in available quantity. Through the kindness of Prof. Hofmann I was enabled to obtain from Gustav Schultz, of tho Berlin anilin factory, a kilogramme of crude Tolidin, and began the study of its derivatives in Berlin three years ago. Some of these compounds have already been described by me, and formed part of a paper read before the British Association in 1886,[2] but others have been obtained since. This paper deals chiefly with those derivatives obtained directly from the base Tolidin, and includes only those secondary derivatives necesary to illustrate completely a particularly reaction of the base itself. The subject is, however, by no means worked out as in a direction indicated at the end of this paper, it gives promise of interesting results yet to be obtained.

The crude base obtained from the factory proved to be the ortho-tolidin, and on purification crystallized in glistening scales of a pale violet hue, melting at 128° C—not at 112°, as was originally stated by Petriew.[3] It turns intensely blue when treated with oxidizing agents, gives a

[1] Journal für practischе Chemie, 101, 92.

[2] Proc. Brit. Ass'n., 1886.

[3] Loc cit.

blue color with ferric chloride when concentrated, and green when dilute, when boiled this turns red and gives a precipitate of ferric hydrate. The sulphate is very insoluble; the hydro-chlorate is soluble in water and in alcohol; it forms with Platinum chloride beautiful yellow acicular crystals, usually in rosettes, insoluble in water and dilute alcohol. These decompose on exposure to moist air, but if dried after precipitation by washing with alcohol and ether, they may be further dried at 100° and analysed. The following results confirm the formula:—

$$\left.\begin{array}{l} C_6\,H_3\,(CH_3)\,NH_2 \\ | \\ C_6\,H_3\,(CH_3)\,NH_2 \end{array}\right\}\,2HCl,\,PtCl_4$$

Calculated.	*Found.* I.	II.
Platinum = 31.07 per cent.	30.81.	30.90.

Cyanide of Tolidin.

Cyanogen gas, evolved by heating mercuric cyanide, was slowly passed through a cold saturated alcoholic solution of Tolidin, till a distinct precipitate occurred, the solution was tightly corked and allowed to stand for forty-eight hours.

A voluminous, brown, amorphous precipitate resulted which, when filtered and washed with alcohol, ether and benzol, was dried and examined. This product was found to be a reddish brown amorphous body, insoluble in water, alcohol, ether or benzol, very slightly soluble in phenol, ligroin and nito benzol. It did not melt at 320°, and burned with difficulty when heated on platinum. It decomposed into tolidin and oxalic acid when heated with acids.

In making the combustion of this substance it was found necessary to add lead chromate to the copper oxide to ensure complete oxidation, and even then the combustion was very tedious. The following figures established the formula:—

$$C_{18}\,H_{16}\,N_4 \quad 2\left\{\,C_6\,H_3\,(CH_3)\,NH_2\,\right\}\,CN$$

Theory.	*Found.* I.	II.	III.
C = 72.72	71.96	71.8	....
H = 6.06	6.11	6.21	....
N = 21.21	....	....	21.43

The Thio-urea.

Twenty grammes of Tolidin in alcohol were boiled with an equal weight of carbon bisulphide in a flask with reversed condenser for six hours. The result was the formation of a white crystalline powder, melting at 185° and insoluble in most media, but soluble in strong sulphuric acid, from which it was precipitated on dilution. Hydrogen sulphide was evolved during the reaction. The resulting compound had the formula: $C_{14} H_{14} N_2 CS$, and the reaction which occurred may be represented thus:

$$\begin{matrix} C_7 H_6 NH_2 \\ | \\ C_7 H_6 NH_2 \end{matrix} + CS_2 = \left.\begin{matrix} C_7 H_6 NH \\ | \\ C_7 H_6 NH \end{matrix}\right\} CS \times H_2 S$$

The following are the analytical results:—

Theory.		Found. I.	II.	III.
$C = 70.86$	per cent.	71.11	71.06	....
$H = 5.50$	"	6.03	5.81	....
$N = 11.02$	"	....	....	....
$S = 12.01$	"	....	....	12.14

All attempts to convert this into an iso-sulpho-cyanide by the usual methods were ineffectual.

Diacetyl Tolidin.

Tolidin, when boiled for a few hours with 7-8 times its weight of glacial acetic acid, in a flask with reversed condenser, readily forms the diacetyl tolidin. The same substance is at once formed in the cold when acetic anhydride is added to a solution of the base. It is a white crystalline powder, melting above 320° and insoluble in the usual solvents. It is deposited, however, in snow white needles on cooling its solution in boiling nitro-benzol; when thus purified and dried at 130° it yielded the following analytical data:—

Calculated for $C_{18} H_{20} N_2 O_2$

Theory.	Found. I.	II.	III.
$C = 72.97$	72.62	72.29	....
$H = 6.75$	6.88	6.59	....
$N = 9.46$	....	....	9.75
$O = 10.81$	....	....	....

Tetra-acetyl Tolidin.

This is probably the most interesting of all the derivations of Tolidin, inasmuch as it is, with one exception, the only example of a primary base in which both of the hydrogen atoms in the amidogen group (NH_2) have been replaced by the acetyl radicle. The only other compound of this class is Diacetanilid.* $C_6 H_5 N (C_2 H_3 O)_2$. Hoffmann prepared this by the action of glacial acetic acid on phenyl mustard oil in a sealed tube at 130°—140 C.

$$C_6 H_5 NCS + 2\, C_2 H_4 O_2 = C_6 H_5 N (C_2 H_3 O)_2 + CO_2 + H_2 S.$$

From the readiness with which the acetyl radicle united with the tolidin it was supposed that a similar compound might be obtained directly by treating diacetyl tolidin with acetic anhydride. Accordingly diacetyl tolidin was, with 6-7 times its weight of acetic anhydride sealed in tubes and submitted to a temperature of 180° C for six hours. The tubes were then found to contain in a dark fluid acicular crystals, which were soluble in alcohol, ether, benzol and and acetic acid, but insoluble in water. After purification, the substance was found to crystallize in long, silky, snow white needles, melting at 210° and on analysis gave the following results :—

Calculated for $C_{22} H_{24} N_2 O_4$

	Theory.	Found. I.	Found. II.
C	69.47	69.28	....
H	6.32	6.61	....
N	7.37	....	7.65
O	16.84	....	....

When treated with dilute alkalies it at once broke down into diacetyl tolidin and acetic acid. The two acetyl derivations of Tolidin may be thus represented :—

$$\begin{array}{l} CH_3 \\ | \\ C_6 H_3 - N \left\{ \begin{array}{l} C_2 H_3 O \\ H \end{array} \right. \\ | \\ C_6 H_3 - N \left\{ \begin{array}{l} H \\ C_2 H_3 O \end{array} \right. \\ | \\ CH_3 \end{array} \qquad \begin{array}{l} CH_3 \\ | \\ C_6 H_3 - N \left\{ \begin{array}{l} C_2 H_3 O \\ C_2 H_3 O \end{array} \right. \\ | \\ C_6 H_3 - N \left\{ \begin{array}{l} C_2 H_3 O \\ C_2 H_3 O \end{array} \right. \\ | \\ CH_3 \end{array}$$

DIACETYL-TOLIDIN. TETRA-ACETYL TOLIDIN.

Dinitio-diactyl-tolidin.

Diacetyl tolidin is easily nitrated when added in small quantities to fuming nitric acid, and the violence of the reaction moderated by surrounding the flask with ice cold water and maintaining a large excess of nitric acid. The mixture is then poured into a long beaker filled with snow and the precipitated nitro body filtered and washed. It is insoluble in alcohol, water and the usual media, but may be, like diactyl tolidin, purified by precipitation from solution in boiling nitro benzol. This compound, at first of a brown tint, can be obtained almost white by repeated recrystallization. It does not melt, and when an attempt was made to purify by sublimation it exploded violently.

On combustion it yielded the following data:—

Calculated for $C_{18}\ H_{18}\ N_4\ O_6$

Theory.	Found.	
$C = 55.96$	55.73	....
$H = 4.66$	4 82	....
$N = 14.51$	....	15.10
$O = 24.87$	....	....

These results are in conformity with the formula:—

$$\begin{array}{l} \quad CH_3 \\ \quad\; | \\ NO_2-C_6\ H_2-N\left\{\begin{array}{l} C_2\ H_3\ O \\ H \end{array}\right. \\ \quad\; | \\ NO_2-C_6\ H_2-N\left\{\begin{array}{l} H \\ C_2\ H_3\ O \end{array}\right. \\ \quad\; | \\ \quad CH_3 \end{array}$$

Dinitro-tolidin.

When the body above described is saponified by prolonged boiling with strong caustic potash a red compound results, which from a large volume of boiling dilute alcohol may be obtained in garnet red tabular crystals which melt at 265° and explode on heating to a higher temperature. It is with difficulty dissolved in any ordinary solvent.

It yielded on analysis the following results:—

Calculated for $C_{14}\ H_{14}\ N_4\ O_4$

Theory.	Found. I.	II.
$C = 55.63$	55.87	....
$H = 4.65$	4.91	....
$N = 18.54$	....	18.10
$O = 21.16$	....	....

This points to the following as the probable formula:—

$$\begin{array}{c} CH_3 \\ | \\ NO_2—C_6\,H_2—NH_2 \\ | \\ NO_2—C_6\,H_2—NH_2 \\ | \\ CH_3 \end{array}$$

It was thought probable that this compound like other nitro derivatives of the aromatic series might be reduced and a tetra-amido derivative thus obtained, but this reduction could not be affected. When dinito tolidin is submitted to the reducing action of nascent hydrogen, evolved either from tin and hydrochloric acid or from sodium amalgam, it breaks down into tolidin, and by no means employed could the nitro groups be reduced to amidogen.

(*Continued.*)

CHEMICAL LABORATORY,
McGill Univ., Med. Faculty.
October, 1889.

L'ABBÉ LOUIS OVIDE BRUNET.[1]

Louis Ovide Brunet, priest in the Archdiocese of Quebec, and Professor of Botany in the University of Laval, was the second son of Jean Olivier Brunet and of Dame Cecile Lagueux, who kept an honorable commercial house in Quebec. He was born in the Lower Town the tenth day of March, 1826. After having pursued a brilliant course of study in the Petite Seminaire, he consecrated himself to the priesthood and was ordained on the first of October, 1848. He was successively Vicar at Notre Dame de Quebec, of St. Joseph de Levis, Missionary at the station of Grosse Isle, and priest at Valcartier. In 1854 he passed to the rectory of St. Lambert, where he remained until his entrance to the Seminary of Quebec.

[1] From L'Annuaire de L'Université Laval, pour L'Année Academique 1877-78.

His very decided taste for communal life, and his rare aptitude for science, caused him for a long time to wish to be admitted into that institution. His desires were at last fulfilled: in 1858 he entered the Seminary as an auxiliary priest, and was immediately charged with the teaching of Botany. There he occupied himself with the organization of a museum, but the difficulties he met with, and the numerous cares of such an undertaking, caused him, at the outset, to wish to visit Europe, in order the better to prepare himself for the teaching of his favorite science. He departed for Europe in 1861. The preparation he made for that purpose, during the two preceding years, rendered his visit most advantageous and productive of good results. After his return, M. Brunet was appointed ordinary professor in the Faculty of Arts, a title which he kept until his death; although sickness obliged him to give up his work in 1870 and leave the Seminary in 1871. He then retired to the privacy of his family, where he enjoyed the society and devoted care of a beloved mother and sister. Madame Brunet died before her son, but Madame Giroux never ceased to surround her brother with the most attentive care until the last.

During his career as professor in the Faculty of Arts, M. Brunet rendered important services to Laval University, which that institution cannot forget. He must, in fact, be regarded as the founder of the Museum of Botany. The Canadian plants which the herbarium now contains, were gathered, for the most part, by himself, and are the fruit of twelve years of earnest work. All were studied and classified by himself. He profited by his voyage to Europe, to give all possible authenticity to his determinations, and in carefully comparing those plants which presented difficulties of determination with original specimens in the herbarium of Michaux at Paris, and of Sir W. Hooker at Kew. After his return from Europe, the new or doubtful plants were submitted to examination by the most distinguished American botanists, such as Dr. Asa Gray, Dr. Engelmann, and others.

For the plants of America outside of Canada, as well as for the general herbarium containing species from all other parts of the world, M. Brunet, always careful to give to his museum an indisputable authority, secured specimens from the most celebrated collectors, as we may see from the following partial enumeration:—

Plants from the Rocky Mountains, from the collections of Hall, Parry and Harbour, named by Asa Gray and Dr. Engelmann

Plants of Illinois and Missouri, from the collections of Reid arranged by Stendel. Also from the collections of Geyer.

Flora of New York from the collection of Leidenberg, named by N. Sonder.

Flora of Texas and vicinity, from collection of Mr. Vincent.

American mosses, from the collections of Sullivant and Lesquereux.

It would also be necessary to mention a large number of plants furnished to M. Brunet by his correspondents as exchanges; among others, by Mosser, Smith and Durand, of Philadelphia. As for the specimens of the general herbarium, it will suffice to name Messrs. Puel, Maille, Borderey, Le Jolis, Verlot, E. Bourgeau, J. Carruel, Balansa, Mougeot and Nestler, to make one realize the value of an herbarium containing collections from so many well known botanists.

An idea of the amount of labor accomplished by the lamented professor, outside of his teaching and other duties, may be gained from the statement that the herbarium of Laval University—thanks to the intelligent care of M. Brunet—contains more than 10,000 specimens, all properly named and classified. In addition to this work, M. Brunet occupied himself in collecting for the benefit of his students a complete series of our Canadian woods. He caused the specimens to be cut in such a manner as to present all the parts of the wood from the bark to the pith. To the collection thus made by himself, he added a number of exotic woods which he obtained from the friends he had made in

France and elsewhere. Being designed wholly for purposes of study, and therefore of small dimensions, these specimens were little calculated to be remarked in a museum and draw attention to the resources offered to commerce and industry by the magnificent species of wood in our forests. Having been charged to prepare collections of Canadian woods for the Universal European Exposition, M. Brunet profited by observations made during the preceding exhibition, and succeeded so well, that he obtained the medal of honour at Dublin in 1865, and again at Paris in 1867. These were the only two occasions on which he had been called upon to compete. Such results, in causing the resources of Canada to be appreciated in Europe, show the high esteem in which he was held. It is hardly necessary to say that the collection for which he received the medal in 1867 was similar to the one which still excites the admiration of all those who visit the museum of Laval University.

M. Brunet was honorably known in Europe and the United States; a member of several learned societies, he counted among his friends men of the highest scientific attainments. He published several botanical articles of merit. They are as follows:—

1. Notes upon the Plants collected in 1859, by L'Abbé Ferland, upon the Coasts of Labrador.

2. Journey of André Michaux to Canada. (Translation by Dr. T. Sterry Hunt in Can. Nat. N. S., p. 325.)

3. Enumeration of the Species of Plants of the Canadian Flora.

4. Catalogue of Canadian Plants contained in the Herbanium of Laval University.[1]

5. History of the Picea found within the limits of Canada.

6. Catalogue of the Ligneous Plants of Canada.

7. Elements of Botany and Vegetable Physiology, with a small flora.

[1] It is to be regretted that M. Brunet was not able to continue this detailed catalogue, which has remained unfinished.

This last work was particularly intended for the use of young ladies in religious institutions. Notwithstanding some incorrectness of style, it has fully answered the purpose of its author, and is yet highly esteemed, because in a small compass, it comprehends all that can interest those for whom it was written.

During his connection with the Seminary, M. Brunet united to his duties as professor of the University, works of a much more modest character, but in which he was equally interested. Gifted with various aptitudes, he willingly occupied himself with everything that might contribute to develop intelligence and taste in children. He taught drawing at the Seminary for several years. During his visit to Europe he had perfected a talent already remarkable, by studying different styles of drawing, and he found many occasions to verify the fact that in an educational institution, one cannot have too much knowledge on different subjects.

Whether in charge of the literary societies, or engaged in the more important duties of his sacred office, he gave to each and all an attention which extended to the minutest details. It was at his suggestion that two divisions of the yearly *retraite* of the Petite Seminaire were made,—the exercises being conducted simultaneously, but separately. The *grande retraite* includes all the classes from the sixth; the *petite retraite*, though it includes only the two lowest classes, numbers, however, 120 to 150 *retraitants*. By this division it became possible to deal with subjects in a manner particularly suited to the members of each division.

Amiable and full of wit, the conversation of M. Brunet was pleasant and cheerful — qualities which caused his colleagues to seek his society. The long illness which brought his life to a close, altered this feature of his disposition, and in the latter part of his life he lived in almost complete seclusion—his best friends having much difficulty in seeing him.

The illness which slowly took his life away assumed a serious character only a few days before his death, which

became known even before the aggravation of his illness was realized. M. Brunet enjoyed lucidity of mind almost to the last. The end came without pain, on the second of October, 1876, at eight o'clock in the evening. He was fifty years of age, exactly twenty-eight of which he passed in the priesthood. His remains rest in the chapel of the Seminary.

An Ancient Blaze.

By D. P. Penhallow.

Somewhat more than four years since, I described[1] an interesting blaze of considerable antiquity, found in the interior of a beech tree when in process of being cut up for firewood. In a more recent publication[2], additional notes were offered, and the statement then made, that the possible date when the blaze was made—assuming the 160 rings of growth to represent exactly as many years, and also assuming that none of the external layers had been removed by decay and other causes—corresponded exactly with the date when the parish of Two Mountains was established, viz., 1721.

It was therefore thought possible that it represented an old boundary blaze, of which there might be others preserved in some of the old trees of the vicinity. This explanation, however, was never a satisfactory one to me, inasmuch as surveyors would hardly undertake so elaborate a figure for such a purpose, nor would they be liable to make the lines of the figure so narrow as to render their early obliteration, within a few months at the farthest, a matter of certainty.

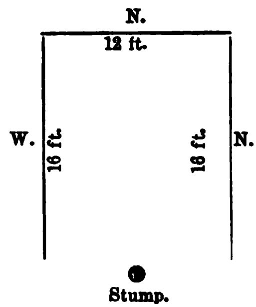
At our request, therefore, Mr. Oswald, who originally discovered the specimen, kindly undertook to make a

[1] Science III., 356.

[2] Trans. R. Soc. Can., V., iv. 50.

thorough examination of the locality. His report is substantially as follows:—

"From the appearance of the ground at the base of the tree, I think there must have been a hut there at one time. There are three mounds of earth forming as many sides of a square. Those forming the two sides, east and west, are about sixteen feet long, while the mound at the north end is about twelve feet long. They are all about two feet high. At the southern end of the square there is no mound, the



earth being at natural level, while at four feet from the probable line of this end, is the stump of the tree from which the blaze was taken. The land to the south rises gradually for one hundred yards, while to the north, for about the same distance, it slopes down towards a small stream where there is every indication of an old beaver dam. The land around it is in heavy bush, and no doubt a century and a half ago, it was in that condition for miles around. I made inquiries of old inhabitants if there were ever any boundary lines near here, and I found there were none. At present, the location is a full mile from the boundary line dividing the parishes of St. Augustin and St. Scholastique, and the Seigniory boundary of the Seminary of St. Sulpice and the Globensky Seigniory, while it is just about the center of the County of Two Mountains." He also dug on the site to a depth of two feet without any result beyond the fact that the earth appeared to be in a natural condition.

These facts must certainly dispose of any possible connection between the blaze and a boundary line, while they also strongly point to the probable fact that a log hut once stood at the foot of the tree, and in decay produced the mounds observed. It is also of interest in this connection to note what we have elsewhere[1] stated, that the Franciscan Hennepin, who was with La Salle from 1679–1682, was traversing this very region of Two Mountains during the years when this blaze was cut, and he speaks of frequently making blazes on trees, as was then customary, the figures taking the form of a cross.

It would appear probable, therefore, from the facts now in our possession, that the blaze was made as a sort of shrine by a trapper or a monk whose hut stood at the foot of the tree, and that it was made by a Franciscan monk would appear most probable from the character of the blaze itself.

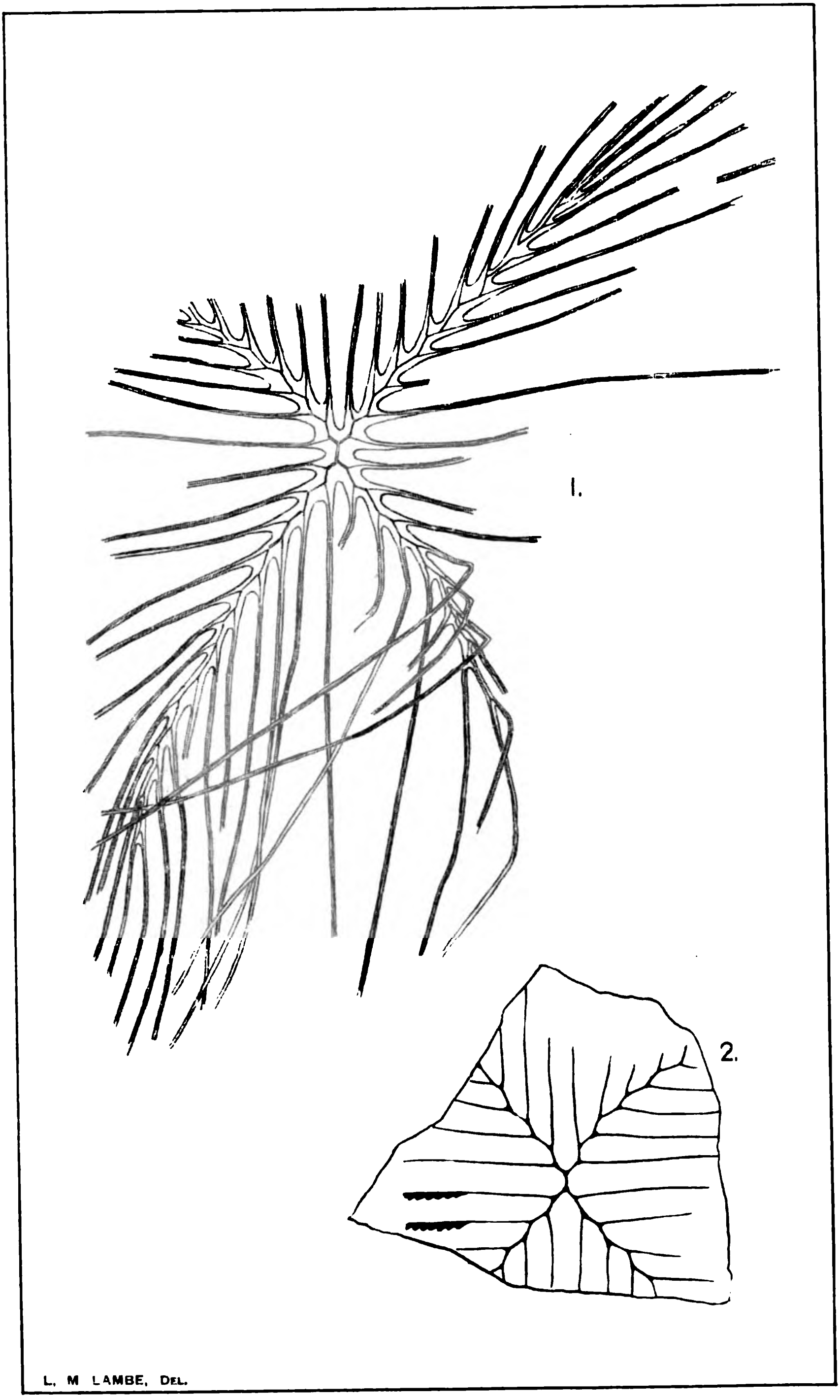
Additional Notes on Goniograptus Thureani, McCoy, from the Levis Formation, Canada.

By Henri M. Ami.

In Vol. III., No. VII., p. 422 of the *Record*, the writer presented a brief paper "on a species of Goniograptus from the Levis formation, Levis, Quebec," in which there was recorded for the first time on this continent the discovery of this interesting genus of siculate graptolites. It was intended to have a *plate* illustrating the Canadian individuals accompanying that paper, but it was unavoidably omitted.

The plate accompanying this note was prepared by Mr. Lawrence Lambe, artist to the Canadian Survey, and illustrates well, two of the best specimens collected by Mr. Weston and Mr. Lambe, in 1886 and 1887, respectively. There are a number of obvious typographical errors, of

[1] Trans. R. Soc. Can., V., v. 50.



AMI ON GONIOGRAPTUS FROM LEVIS, QUEBEC.

little import, in that paper (*loc. cit. supræ,*) whilst one or two less obvious corrections are hereby submitted.[1]

On page 426 and line 12 from the bottom the text reads: "The angle which these celluliferous stipes make with the general direction of the arm is generally 450°" The angle here meant is 45° not 450°.

On the same page, in the preceding paragraph, it is stated of the arms that "all four are sub-equal, disposed regularly and symmetrically, so as to form a large + shaped figure." This statement might be modified so as to indicate the exact angles made by the arms; that they are disposed so as to form a polypary with two series of arms and areas included within or between the arms, one set of which contains an angle of seventy-five degrees, and the other or larger angle, one hundred and five degrees.

The excellent figures by Mr. Lambe are exact reproductions of the specimens in the national collections of the Geological Survey Museum, Ottawa, and indicate admirably the mode of growth of the polypary. Only in fig. 2, the smaller specimen, are there any hydrothecæ visible.

Although the material very kindly placed at the disposal of the writer by Dr. Selwyn and Mr. Whiteaves is excellent, and presents new features respecting the morphology and development of *Goniograptus*, it is nevertheless hoped that additional material will be forthcoming whereby all the generic and other relations of this interesting member of the disc-bearing group of graptolites can be studied and ascertained.

It might be interesting here to add that the following species occur in the same measures with *Goniograptus Thureani*, McCoy var. Selwyni, *nobis*, viz:—

Tetragraptus quadri-brachiatus, Hall; *T. approximatus*, Nicholson; *T. fruticosus*, Hall; *T. serra*, Brongniart; (=*T. bryonoides*, Hall); *Dichograptus octo-brachiatus*, Hall; D. (?) *ramulus*, Hall; *Drityograptus* sp., and *Lingula Irene*, Billings.

[1] The paper in question was published during the author's absence in Europe, so that he had not opportunity of correcting the proof.

Book Notices.

Text-Book of Botany.[1]—This most recent of American Text-Books of Botany is dedicated to the illustrious memory of Antoine L. De Jussieu, upon whose inductive method the course of study is based. The first part deals with instructural and systematic botany, touching briefly upon some of the more important physiological processes. Part II., Phytology, opens with a pretty full list of abbreviations used, a most useful list of etymons, and a very full list of proper names. The remainder of the work—169 pages—is taken up by a "Manual of Plants, including all the known orders with their representative genera."

There is little evidence of advance beyond what has been stated in previous text-books. We note, however, as announced in the preface, that the sequence of the leading divisions of the Phanerogams—Class I. Gymnosperms and Class II. Augiosperms—is more in accord with present views than what is usually found in our unrevised text-books. The figures are good, and for the most part fresh—a few being original.

The treatment is clear and concise, but in the use of similes is often inclined to be trivial—a style quite out of place in a scientific treatise. The attempt to cover too much ground within a very limited space has resulted—as must be expected under such circumstances—in a breviety of statement which must often leave the student without any clear conception of the particular subject. So far as the systematic and structural portion is concerned, this difficulty would be overcome by a competent teacher, but for the student under the ordinary circumstances of academic instruction, the fault is a serious one. It becomes more marked in the Manual, where brevity and condensation is carried to such an extreme as to render this part of the work of little or no value for the determination of species by those who have not already gained a considerable experience in the analysis of plants.

When a new work such as this appears, one naturally looks to it as giving recognized facts of fairly recent date, and it is disappointing to find, page 46, that the leaves of Welwitschia are spoken of as persistent cotyledons; page 70, and in the chart, page 69, the term Azoic is retained instead of Eozoic, while the statement is made, notwithstanding the known presence of *Eozoon Canadense* and graphite in the Laurentian formation, that no life appeared until the Palæozoic; the cells of Diatoms are rich in starch, p. 25;

[1]Botany for Academies and Colleges, with a Manual of Plants. By Annie Chambers-Ketchum, A.M. J. B. Lippincott & Co., 1889. 8vo, pp. 190 and 169.

the term radicle is still applied to the caulicle of the embryo; the obsolete term spongioles, is given a definite value ; while on p. 163 we are left to infer that soda is present only in marine plants. No doubt these mistakes will be eliminated from the next edition· Though hardly adapted to the requirements of a college, the book will doubtless serve a very useful purpose, and we are certainly disposed to give it a welcome, as promising evidence of zealous work by a lady.

P.

GRAY'S SCIENTIFIC PAPERS.[1]—The most important of recent botanical publications, and one which will be received with the greatest favor wherever botanical research is prosecuted, is the collection of scientific papers by Dr. Gray, recently issued in a most attractive form, under the editorship of Prof. Sargent. The present issue embraces two volumes, a third to follow, as we may infer from a statement in the preface.

The voluminous character of Dr. Gray's writings is well known to botanical students, but, as the editor correctly deserves, "The number of his contributions to science and their variety is remarkable, and astonishes his associates even, familiar as they were with his remarkable intellectual activity, his various attainments, and that surprising industry which neither assured position, the weariness of·advancing years, nor the hopelessness of the task he had imposed upon himself ever diminished." There will, therefore, be a well nigh universal feeling of regret for the necessity which compelled exclusion of "a number of papers of nearly as great interest and value as those which are chosen."

The writings are grouped in four divisions, according to the particular subjects dealt with. "The first in importance contains his contributions to descriptive botany. These, with few exceptions were devoted to the flora of North America, and although it did not fall to his lot, as it did to that of some of his contemporaries, to elaborate any one of the great families of plants, the extent and character of his contributions to sympathetic botany will place his name among that of the masters of the science.

"His works, of a purely educational character, are only second in importance to his writings on the flora of North America; and their influence upon the development of botanical knowledge in this country, during the half century which elapsed between the publication of the first and the last of the series, has been great and must long be felt. No text-books of science surpass them in the

[1]Scientific papers of Asa Gray, selected by Charles Sprague Sargent; Houghton, Mifflin & Co., 1889. 2 vols. 8vo., pp. 397 and 498.

philosophical treatment of the subjects they embrace, or in the beauty and clearness of their style.

A series of critical reviews of important scientific publications, and of historical accounts of the lives and labors of botanical worthies, may be conveniently grouped in the third division of Professor Gray's writings; while in the fourth fall a number of papers which owe their existence to the discussions which followed the publication of Mr. Darwin's 'Origin of Species'—discussions in which Professor Gray took, in this country, the foremost position."

For the re-publication of the first and second divisions, there is no present necessity. The most important of the philosophical essays "which grew out of the discussion of the Darwinian theory, have already been re-published by their author," and are, therefore, available. The two volumes now belore us, therefore, embrace many of the most important scientific articles, reviews and biographical sketches which Dr. Gray wrote during that long period of an unusually active and brilliant career, extending from 1834 to 1887. As many of the valuable papers now left are beyond the reach of most botanical students of the present day, it is to be hoped means may be provided for their re-publication at a later date as a fourth volume of the present series.

The writings of Dr. Gray possess a peculiar interest, not only from the fact that they cover a period of somewhat more than fifty years, but because we also have in them a history of botanical science during a period pregnant with the most important developments—a period which has given birth to an entirely new school, of which Dr. Gray was himself one of the most brilliant leaders.

As a critic, " his reviews represented the opinion of a just and discriminating mind, thoroughly familiar with all sides of the question before it, critical rather than laudatory, loving the truth and its investigators, but the truth above everything else. No other naturalist of his reputation and attainments ever devoted so much time to literary work of this sort, or continued it so uninterruptedly for so many years; and in our time, the criticism and advice of no other botanist has been so eagerly sought or so highly valued by his contemporaries."

The thanks of botanists everywhere are due Professor Sargent for the service he has rendered them and science, in this compilation.

P.

INDEX.

ABSTRACT FOR THE M

Meteorological Observations, McGill College Observatory, Montreal, C

DAY.	THERMOMETER.				BAROMETER.				† Mean pres-sure of vapour.
	Mean.	Max.	Min.	Range	*Mean.	§Max.	§Min.	§Range.	
1	76 75	87.5	66.0	21.5	30.1672	30.200	30.124	076	.6135
2	75 42	82.3	68.2	14.1	30.1308	30.194	30.059	.135	.6422
3	75.05	82 0	69.2	12.8	29.8837	30 045	29.727	.318	.7308
4	70.07	77.0	59.3	17 7	29.7755	29.979	29.638	.341	.5918
5	64.52	75.0	54.4	20.6	30 1163	30.146	30.060	.056	.3748
6	68.25	77.5	57.3	20.2	30.1762	30.247	30.111	.136	.4035
SUNDAY........ 7	.....	74.8	63 1	11.7	....	......	......	....	...
8	74.00	82.0	67.0	15 0	29.9125	29.926	29.899	027	.6155
9	62.72	71.6	58 9	12.7	29.9975	30.024	29.978	.046	.4968
10	67.92	76.1	59 3	16.8	29.9673	39 001	29.933	.068	.5472
11	66.10	72 6	61 3	11.3	29.8870	29 957	29.856	.101	.5805
12	65.00	72.5	58.8	13 7	29.9992	30.026	29.963	.063	.4965
13	67.65	78.0	59.3	18.7	29.8140	29 929	29.710	.219	.5703
SUNDAY........14	.....	71.0	58.3	12.7	....	.....		....	.....
15	61.65	69 9	53.4	16.5	29 8465	29 885	29.813	.072	.3683
16	66 02	77 1	57.3	19 8	29.7987	29 840	29.746	.094	.4695
17	64.67	72.5	59.0	13 5	29 8918	29 932	29.813	.119	.4430
18	68.75	77.0	58.3	18 7	29 8763	29.940	29.791	.149	.4802
19	71.13	80.8	64.2	16 6	29 7223	29.785	29 644	.141	.5997
20	68.63	74.9	64 5	10.4	29.7025	29.831	29.582	.249	.5625
SUNDAY........21	.....	80.0	61.5	18.5	...	......		....	.....
22	71.25	80.9	61.2	19 7	29 8633	29 939	29 775	.164	.5285
23	65.48	74 9	58.5	16.4	29 7227	29.798	29.653	.145	.4788
24	59 78	69.9	56.0	13.9	29 8777	29 953	29.822	.131	.3518
25	61.98	70.0	52.3	17.7	30 0190	30 062	29.982	.080	.3402
26	65.67	73.9	52.4	21.5	30.1002	30.144	30.064	080	.3323
27	63.33	72 0	57.9	14.1	29.9635	30.038	29 876	.162	.4635
SUNDAY.. 28	.....	77 9	59.2	18.7	....	29 884	29.750	...	....
29	71.68	79 6	66.2	13.4	29.8023	30 037	29.923	.134	.6388
30	69 28	75.5	65.3	10.2	29.9570	30.138	30.064	.114	.6125
31	72.57	81.0	65.3	15.7	30.1005	......	......	.074	6135
....Means	67.97	76.38	60 42	15.96	29 9286	......	....	131	.5165
15 yrs. means for & including this mo.	69 02	77.34	60.02	16.32	29 8815	......	....	.1396	.5011

ANALYSIS OF WIND RECORD.

Direction.......	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
Miles..	998	518	234	1126	1529	2481	1394	998	
Duration in hrs..	95	51	32	103	121	164	94	84	
Mean velocity...	10.51	10.16	7.31	10.93	12 64	15.13	14.83	11.88	

Greatest mileage in one hour was 31 on the 4th and 20th.

Resultant mileage, 3,170

Resultant direction, S 51° W.

Total mileage, 9,279.

ONTH OF JULY, 1889.

anada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

‡ Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
67.7	64.7	S.	9 0	2.0	5	0	89	....	....	....	1
73.8	66 2	S.	14.2	5 5	10	1	65	Inapp.	....		2
84 2	69 8	S.E	12.3	8.5	10	4	00	0.10	....	...	3
79.7	63.2	S.W.	20.9	6.2	10	2	41	1.03	....		4
62.0	51.0	N.W.	10.8	0.8	5	0	100	....	. .	....	5
59.7	53 0	S.W.	8.6	2.5	10	0	89	....	....	...	6
....	....	S.W.	22.1	....	..		04	0.3	....	....	7 ....SUNDAY
74 0	64.8	W.	8.6	9.5	10	3	31	0.02	...	...	8
87.0	58 7	N.E.	13 0	10.0	10	10	00	0.11	....	..	9
80.2	61.5	N.E.	10.9	6.8	10	1	34	...	...	..	10
90 5	63 0	N.E.	7 9	10.0	10	10	25	0.52	...	....	11
80.8	58.8	N.E.	7.9	8.2	10	0	34	...	....	....	12
84.7	62.5	S.E.	8.7	8.0	10	1	28	0.42	....	....	13
....	....	N.W.	10.7	...	.	..	67	. . .	....	...	14 ....SUNDAY
67.0	50.3	N.	10.7	6.7	10	0	48	0.03	....	..	15
74.3	57 0	W.	19.0	7 2	10	3	48	0 36	....	....	16
73.0	55.7	W.	13.9	3.8	9	0	72	Inapp.	...	....	17
68.7	57.8	S.	11.4	2.2	10	0	98	...		......	18
79.0	63.8	S.	9.3	10.0	10	9	18	0.23	....		19
80 8	62.3	N.	15.5	10.0	10	10	19	2.00	....	....	20
...	....	N.W.	11.2	....	..	.	99	....	.	....	21 ....SUNDAY
69.3	60.2	S.W.	7 1	3 3	10	0	92	....	...	....	22
76.2	57.7	S.W.	19 0	4 5	10	0	61	0.10	..	...	23
68.7	49.0	W.	14.7	6.7	10	0	36	0 04	.	... .	24
61.5	48.0	W.	13.7	3.0	8	0	85	Inapp.	. .	....	25
53.8	47.7	E.	6.2	2 0	7	0	100		. .	....	26
80.7	56.8	S. E.	12 0	8.8	10	3	02	0 78		....	27
..	....	S. E.	16.3	....	..	..	66	0.28		....	28 ....SUNDAY
82.3	65.7	S.	17 9	9.3	10	7	17	0.97		...	29
85.7	65.0	S.W.	13.2	8 0	10	1	27	0 14	.	...	30
77.8	64.7	S.W.	9 8	8.2	10	0	64	....	..	....	31
74.9	59.2	....	12 47	6 36	.	..	50.3	7.16	....	..	Sums ....
70 9	....	...	..	5.42	..	..	¶59.2	4 25	....	..	15 years means for and including this month.

*Barometer readings reduced to sea-level and temperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 87.5 on the 1st; the greatest cold was 52.3 on the 25th, giving a range of temperature of 35.2 degrees. Warmest day was the 1st. Coldest day was the 24th. Highest barometer reading was 30,247 on the 6th; lowest barometer was 29.582 on the 20th; giving a range of 0.665 inches. Maximum relative humidity was 97 on two days. Minimum relative humidity was 38 on the 26th.

Rain fell on 20 days.

Hail fell on 1 day.

Auroras were observed on 3 nights.

Thunderstorms on 5 days.

NOTE.—The rainfall is the greatest recorded in July, in 15 years; and is the greatest for any one month during that time, except the month of August, 1888 (rainfall 7.89) and October, 1885; (rainfall 7.17).

ABSTRACT FOR THE MO

Meteorological Observations, McGill College Observatory, Montreal, (

DAY.	THERMOMETER.				BAROMETER.				† Mean pressure of vapour.
	Mean.	Max.	Min.	Range	*Mean.	§Max.	§Min.	§Range.	
1	66.72	72.5	63.4	9.1	30.0460	30.148	29.965	.183	.6162
2	70.53	79.1	63.2	15.9	29.9000	29.976	29.841	.135	.6185
3	68.97	78.6	61.1	17.5	29.8603	29.918	29.816	.102	.5633
SUNDAY........ 4	.....	73.5	57.4	16.1	....	......	.....	....	.....
5	61.57	70.0	58.3	11.7	30.0587	30.113	30.035	.078	.4290
6	64.40	73.0	55.4	17.6	30.1103	30.161	30.060	.101	.3930
7	62.67	70.9	54.9	16.0	30.1428	30.194	30.108	.086	.3657
8	62.37	73.0	51.9	21.1	30.1227	30.215	30.014	.201	.3903
9	66.52	74.0	59.2	14.8	29.8567	29.976	29.787	.189	.5498
10	64.90	70.4	59.1	11.3	29.8165	29.848	29.788	.060	.4638
SUNDAY........11	.....	63.7	52.4	11.3	....	......	...	....	.....
12	58.42	67.3	50.4	16.9	30.0043	39.043	29.959	.084	.3615
13	60.05	68.3	52.4	15.9	30.0845	30.102	30.041	.061	.3423
14	59.98	64.7	55.0	9.7	29.9015	30.049	29.738	.311	.3952
15	61.13	66.5	56.4	10.1	29.7532	29.828	29.677	.151	.4507
16	61.30	68.1	54.3	13.8	29.8400	29.857	29.824	.033	.4130
17	63.38	71.0	56.4	14.6	29.9198	29.973	29.854	.119	.4558
SUNDAY........18	. ...	71.7	57.8	13.9	....	......	.....	....	.....
19	64.10	68.6	58.4	10.2	29.9437	29.974	29.915	.059	.4978
20	68.28	74.9	63.6	11.3	29.9353	29.960	29.916	.044	.5353
21	68.93	76.3	63.0	13.3	29.7658	29.882	29.668	.214	.6122
22	65.90	72.0	61.4	10.6	29.8083	29.855	29.730	.125	.4643
23	65.48	75.2	58.8	16.4	29.9660	30.051	29.888	.163	.4593
24	61.47	68.6	53.9	14.7	30.1452	30.190	30.102	.088	.3938
SUNDAY........25	.....	70.0	52.0	18.0	....	......	......	.. .	.....
26	61.47	71.5	50.1	21.4	30.2852	30.319	30.250	.069	.4125
27	66.58	76.0	59.1	16.9	30.2552	30.329	30.192	.137	.4863
28	69.67	79.3	59.2	20.1	30.1938	30.248	30.147	.101	.5295
29	71.32	81.1	60.3	20.8	30.0965	30.153	30.041	.112	.5568
30	71.70	79.0	66.3	12.7	30.0608	30.125	50.032	.093	.5068
31	65.38	73.9	59.3	14.6	30.2595	30.293	30.187	.106	.3755
....Means	64.97	72.35	57.56	14.78	30.0049	......	......	.118	.4681
15 yrs. means for & including this mo.	67.10	75.38	58.96	16.42	29.9397	......	......	.129	.4840

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
Miles............	661	686	460	177	927	4344	1725	257	
Duration in hrs..	59	66	45	22	86	298	134	34	
Mean velocity...	11.2	10.4	10.2	8.0	10.8	14.6	12.9	7.6	

Greatest mileage in one hour was 27 on the 30th.
Resultant mileage, 4,805.

Resultant direction, S 54° W.
Total mileage, 9,237.

NTH OF AUGUST, 1889.

anada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

‡ Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles per hour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
94.2	65.0	S.	6 3	8.3	10	0	00	0.68	....	....	1
84.2	65.0	S.	10.6	8.5	10	1	42	0.11	....	. .	2
79.8	62.3	S.W.	16.5	6.3	10	0	50	0.04	....	....	3
....	....	S.W.	14.9	....	..		51	0.13	....	....	4 ....SUNDAY
78.2	54.5	W.	7.6	6.8	10	0	28	0.02	.. .	....	5
66.5	52.2	S.W.	15.9	2.8	10	0	98	....	....	....	6
65.2	50.2	W.	8.4	2.2	9	0	86	....	....	....	7
67.7	52.0	S.W.	6.3	7.0	10	0	85	....	....	....	8
84.5	61.5	S.W.	15.8	9.8	10	9	02	0.04	....	...	9
75.7	56.8	W.	11.6	8.5	10	1	45	0.26	....	....	10
...	....	W.	14.7	....	..	..	46	....	....	....	11 ....SUNDAY
75.0	50.0	S.W.	15 3	5.7	10	0	77	Inapp.	....	....	12
67.0	48.5	W.	6 9	7.2	10	0	83	. .	....	....	13
76.3	52.0	E.	16.5	10.0	10	10	00	0.63	....	....	14
84 2	55.8	S.W.	14.1	9.7	10	3	21	0.51	....	...	15
76.8	53.3	S.W.	9 5	6.7	10	0	65	0.06	....	....	16
79.2	56.3	W.	14.4	9.0	10	7	66	....	....	....	17
..	....	S.W.	15.7	....	..	..	60	....	...	......	18 ....SUNDAY
83.2	58.5	S.W.	18.2	9.5	10	7	03	....	....		19
78.0	60.8	W.	9.5	5.7	10	0	75	....	....	....	20
86.5	64.7	S.W.	14.8	8.8	10	3	01	0.23	...	....	21
73.5	57.0	S.W.	17.7	3.5	10	0	76	....	....	....	22
74.5	56.7	S.W.	15.2	4 7	10	0	92	0.02	....	....	23
72.3	52.2	N.E.	12.3	5 0	10	0	69	....	....	....	24
....	....	N.E.	7.6	....	..	..	99	....	....	....	25 ....SUNDAY
74.8	53.5	N.E.	9 5	2 2	9	0	93	....	....	....	26
75.5	58.2	S.W.	12.0	2 5	10	0	70	....	....	....	27
74.3	60.7	S.W.	4.4	0.5	2	0	94	....	....	....	28
73.5	62.2	S.W.	9.2	3 0	10	0	84	....	....	....	29
64.8	59.2	S.W.	19.3	4.8	8	0	77	..	....	....	30
60.8	51.0	N.E.	13.8	2.2	8	0	90	...	...	....	31
75.8	56 7	S. 54° W.	12 40	5 96	.		59.0	2.73	....	....	Sums ....
72.5	....	....	....	5.36	..	..	60 4	2 83	..	....	15 years means for and ncluding this month ..

•Barometer readings reduced to sea-level and temperature of 32° Fahr.

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100.

¶ Eight years only.

The greatest heat was 81.1 on the 29th; the greatest cold was 50.1 on the 26th, giving a range of temperature of 31.0 degrees. Warmest day was the 30th. Coldest day was the 11th. Highest barometer reading was 30.329 on the 27th; lowest barometer was 29.668 on the 21st; giving a range of 0.661 inches. Maximum relative humidity was 98 on the 1st and 15th. Minimum relative humidity was 42 on the 6th.

Rain fell on 13 days.

Auroras were observed on 1 night.

Fog on 4 days.

Thunderstorms on 6 days.

ABSTRACT FOR THE MO

Meteorological Observations, McGill College Observatory, Montreal

DAY.	THERMOMETER. Mean.	Max.	Min.	Range	BAROMETER. *Mean.	§Max.	§Min.	§Range.	† Mea pres- sure o vapou
SUNDAY........ 1	.....	75.9	55.1	20.8	......	.....	......	....	....
2	67.92	77.5	55.1	22.4	30.1868	30.258	30.113	.145	.5007
3	69.32	79.2	59.5	19.7	30.0803	30.126	30.040	.086	.5373
4	70.70	82.1	60.4	21.7	30.0582	30.113	30.022	.091	.5732
5	70.32	77.0	62.9	14.1	29.9788	30.037	29.930	.107	.5493
6	64.35	72.0	57.1	14.9	30.0150	30.170	29.903	.267	.5142
7	61.53	66.9	54.0	12.9	30.1903	30.253	30.123	.130	.4537
SUNDAY. 8	.....	73.4	58.1	15.3	......	......	.....	....	.....
9	67.70	77.1	57.5	19.6	30.2428	30.284	30.208	.076	.4777
10	68.03	78.8	60.1	18.7	30.2333	30.264	30.217	.047	.5310
11	69.12	80.1	59.9	20.2	30.2030	30.260	30.164	.096	.5055
12	68.97	80.4	58.4	22.0	30.1997	30.224	30.171	.053	.5168
13	67.05	75.5	62.1	13.4	30.2153	30.273	30.151	.122	.4710
14	69.83	78.7	60.3	18.4	30.1845	30.232	30.147	.085	.5680
SUNDAY.. 15	.....	81.0	63.8	17.2	......	.....	......	...	.....
16	62.82	74.9	54.1	18.8	29.9733	30.069	29.910	.159	.5240
17	53.75	56.1	50.2	5.9	29.9817	30.061	29.867	.194	.3880
18	54.95	59.2	51.4	7.8	29.7963	29.811	29.776	.035	.3763
19	49.17	52.3	47.0	5.3	29.5155	29.782	29.376	.406	.3137
20	51.32	54.0	47.5	6.5	29.3262	29.362	29.292	.070	.3473
21	49.02	53.0	45.5	7.5	29.4458	29.649	29.281	.368	.3068
SUNDAY.. 22	.....	52.0	39.6	12.4	.....	......	.....	....	....
23	48.80	57.1	38.6	18.5	30.0125	30.070	29.943	.127	.2113
24	56.22	65.0	48.2	16.8	30.0550	30.096	30.025	.071	.2925
25	59.40	71.2	45.7	25.5	30.0005	30.081	29.928	.153	.3418
26	55.78	62.5	47.5	15.0	29.8337	29.882	29.792	.090	.3875
27	47.08	55.0	43.5	11.5	29.9225	29.993	29.857	.136	.2487
28	43.50	50.9	38.7	12.2	30.0630	30.133	30.028	.105	.2052
SUNDAY........29	.....	48.5	37.7	10.8	....	......	.....	....	....
30	51.70	62.0	40.6	21.4	29.8747	30.010	29.668	.342	.3517
....Means.	59.93	67.58	52.00	15.57	29.9835	......	.....	.142	.4197
15 yrs. means for & including this mo.	58.56	66.60	50.83	15.77	30.0065	.....	.....	.179	.3804

ANALYSIS OF WIND RECORD.

Direction........	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.
Miles............	527	940	252	1301	1911	1751	2037	231	
Duration in hrs..	51	97	42	118	147	105	129	20	11
Mean velocity...	10.3	9.7	6.0	11.0	13.0	16.7	15.8	11.6	

Greatest mileage in one hour was 32 on the 9th.

Resultant mileage, 3,155.

Resultant direction, S 30° W.

Total mileage, 8,950.

TH OF SEPTEMBER, 1889.

anada, Height above sea level, 187 feet. C. H. McLEOD, *Superintendent.*

Mean relative humidity.	Dew point.	WIND. General direction.	WIND. Mean velocity in miles perhour	SKY CLOUDED IN TENTHS. Mean.	Max.	Min.	Per cent of possible sunshine.	Rainfall in inches.	Snowfall in inches.	Rain and snow melted.	DAY.
....	....	N.E.	6.6	....	..		91	....	....	....	1 ....SUNDAY
74.2	58.8	S.	9.3	6.8	10	0	75	....	....		2
70.7	61.0	S.	9.5	6 5	10	0	75	....	....	...	3
77.0	62.8	S.E.	5.5	3.7	10	0	79	....	....		4
75.0	61.5	S.	14.1	5 0	9	0	54	....	.	....	5
85.0	59.7	S.W.	16.9	7.8	10	0	03	0.12	....	....	6
83.5	56.0	E.	6.3	8.3	10	0	07	...	....	....	7
....	....	......	1.9	....	.	..	77	....	...	....	8 ....SUNDAY
72 0	57.7	N.E.	9.3	0.0	0	0	98	....	....	...	9
78.7	60.7	N.E.	11.2	6.8	10	0	56	....	..	...	10
73.5	59 2	N.E.	13.1	0.8	5	0	88	....	....	....	11
74.0	59.7	N.E.	10.5	3.7	10	0	88	....	....	....	12
71.8	57 0	S.E.	8.8	8.7	10	0	05		...	....	13
76.8	62.2	S.E.	15.4	7.0	10	0	39	Inapp.	....	....	14
...	....	S.	15.7	..	..	.	75	...	....	....	15 ....SUNDAY
89.3	59.8	N.	14.0	8.3	10	0	00	0.74	....	....	16
93.7	52 0	N.E.	7 7	10 0	10	10	00	0 85	....	....	17
86.5	50 8	S.W.	12.2	7.0	10	0	10	1.06		......	18
89.7	46 2	W.	18.2	8.8	10	5(?)	00	0.54	....		19
91 7	49.0	S.	15.9	10 0	10	10	00	0.40	....	....	20
87.5	45.3	W.	16.0	8 3	10	0	00	0.40	.	....	21
	....	W.	22.9	....	10	.	40	Inapp.	...	....	22 ....SUNDAY
62 3	35.8	W.	20.3	1.8	10	0	95	.	....	....	23
65 8	44.0	S.	9 0	2 0	10	0	53	....	.	....	24
70 3	48.2	S.	11.1	1.7	10	0	92	...	.	....	25
85.3	51 5	S.W.	20.0	9.3	10	6	00	0.23	.	....	26
77.2	40 0	W.	14 7	8.0	10	0	49	0.05		...	27
72.7	35.0	W.	14.3	5.2	10	0	30	0 07		....	28
..	..	W.	11.3	....		..	62	0.09		...	29 ...... SUNDAY
90.0	48.5	S.	11 3	9.8	10	9	10	0.08	...	....	30
79.21	52 9	......	12 43	6 21	.		45.0	4.63	....	....	Sums ....
74 94	...	......	....	5 69		.	¶54.4	3 33			15 years means for and including this month

*Barometer readings reduced to sea-level and temperature of 32° Fahr

§ Observed.

† Pressure of vapour in inches of mercury.

‡ Humidity relative, saturation being 100

¶ Eight years only.

The greatest heat was 82 1 on the 4th; the greatest cold was 37.7 on the 29th, giving a range of temperature of 44.4 degrees. Warmest day was the 15th. Coldest day was the 29th. Highest barometer reading was 30.370 on the 1st; lowest barometer was 29.281 on the 21st; giving a range of 1.089 inches. Maximum relative humidity was 99 on the 17th. Minimum relative humidity was 39 on the 25th.

Rain fell on 14 days.

Aurora on 1 night.

Fog on 6 days.

NOTICES.

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